



Glacier Bay National Park and Preserve Kittlitz's Murrelet Monitoring Protocol

Version KM-2012.1

Natural Resource Report NPS/SEAN/NRR—2013/735



ON THE COVER

Murrelets in the West Arm of Glacier Bay, Alaska

Photograph by: Brendan J. Moynahan

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Revision History

This Kittlitz’s murrelet monitoring protocol is identified with the characters “KM-” followed by the year submitted to formal peer review followed by a sequence number indicating the revision for that year, beginning with one. This controlled method is required because most monitoring program data products are internally stamped with the protocol ID used for their creation pointing to the specific document whose exact processes and definitions those data reflect. Protocol ID stamping is done down to the individual data record level.

The protocol is a monolithic package consisting of narrative chapters, appendices, and standard operating procedures (SOP s). In the event a revision is made to any part of the package, a whole new package is issued with its own unique protocol identifier using the process explained in SOP 10.

Revision History Log:

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Abstract

The Kittlitz's murrelet (*Brachyramphus brevirostris*, hereafter "KIMU") is a seabird endemic to Alaska and northeastern Russia. Because of their role as integrators of marine and terrestrial ecosystems and intrinsic conservation concern, breeding season populations of KIMU and co-occurring marbled murrelets (*B. marmoratus*, hereafter "MAMU") in Glacier Bay National Park and Preserve (hereafter "GLBA") were selected for the Southeast Alaska Network (SEAN) Vital Signs Monitoring Program. Primary murrelet monitoring objectives are annual estimation of on-water abundance and spatial distribution for populations of each species and high power to detect 33% KIMU population decline over 15 years.

In early July each year, SEAN staff conduct boat-based line transect surveys totaling approximately 250 km within 1,170 km² of Glacier Bay proper (hereafter "Glacier Bay"). Sampling challenges inherent to our study system include incomplete detection and species identification of murrelets, large spatial and temporal variation in populations, and complex topography of glacial fjords. Key mitigating elements of the monitoring protocol include an augmented serially alternating panel design, spatially-balanced sampling stratified by expected KIMU density, transects 4-8 km in length oriented from shore-to-shore, and analytic methods accounting for incomplete detection and species identification of murrelets. We projected that meeting monitoring objectives was plausible but uncertain, depending largely on future magnitude of annual variation in KIMU abundance.

This protocol provides information necessary to implement and sustain a long-term murrelet monitoring program, including context and justification for monitoring, description of survey methods, delineation of staff roles, and detailed instructions for field set-up, maintenance, training, data collection, storage, analysis, and reporting. Data and report products concerning murrelet monitoring in Glacier Bay will be disseminated to NPS personnel and outside parties on the SEAN web site.

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1.0 Background and Objectives

1.1 Protocol Synopsis

Monitoring the status (abundance and density) and spatial distribution of KIMU populations in GLBA is part of the National Park Service (NPS) SEAN Vital Signs Monitoring Program. SEAN has selected twelve priority natural resources for long-term monitoring based on their inherent natural value, susceptibility to alteration by human stressors, and specific resource management importance to parks (Moynahan et al. 2008). Although SEAN monitors natural resources in three Southeast Alaska national parks, KIMU are monitored only within marine habitat of Glacier Bay (Figure 1.1), which supports a large summer population (Hoekman et al. 2011a, b).

SEAN, in cooperation with staff from University of Alaska-Fairbanks, developed this protocol in accordance with NPS standards (Oakley et al. 2003), which include a generalized narrative and detailed Standard Operating Procedures (SOPs) that guide every step of the program. Multi-year development of this protocol culminated in a novel sampling design for detecting change in the status and spatial distribution of co-occurring KIMU and MAMU populations in Glacier Bay (Hoekman et al. 2011a, b, c).

1.2 KIMU Life History and Habitat Requirements

The KIMU is a seabird endemic to Alaska and northeastern Russia, with the highest population densities in the northern Gulf of Alaska (Day et al. 1999). KIMU aggregate inshore during the breeding season (April-August), often in glacial fjord habitats, but also in areas such as the Aleutian Islands and far-eastern Russia with only remnant or previous glacial influence (USFWS 2013). In glacial fjords, KIMU often forage near tidewater glacier outflows (Day and Nigro 2000, Kuletz et al. 2003, Arimitsu et al. 2012), and nests are dispersed in remote, recently de-glaciated areas with sparse vegetation (Day 1995, USFWS 2013). KIMU reliance on pelagic prey sources and glacially-influenced habitats link their population trends and spatial distribution to dynamic physical habitat variables such as glacial extent and oceanography that are, in part, subject to chronic changes due to climate change (Arendt et al. 2002, Larsen et al. 2007).

KIMU are thought to live 15 to 25 years, achieve reproductive maturity around 2 to 3 years, breed intermittently, and lay one egg per breeding season (Day et al. 1999, USFWS 2013). Migratory habits of KIMU summering in GLBA are unknown. Birds summering in Icy Bay have travelled to the Alaska Peninsula before transmitter signals were lost in fall (J. Piatt and M. Kissling, unpublished data). Large populations have been observed on the Alaska Peninsula during September and October (Day et al. 2011). Most KIMU are thought to winter in the Bering Sea (Day et al. 1999, USFWS 2013).

1.3 Glacier Bay

Glacier Bay is a narrow, ~100 km long fjord (Figure 1.1) characterized by numerous arms and small inlets, the upper reaches of which receive discharges of turbid water and ice from numerous glaciers. Complex bathymetry, produced by numerous deep basins and sills, creates large variations in depth, tidal influence, water temperature, salinity, turbidity, and productivity (Etherington et al. 2007). For a more detailed description of Glacier Bay's natural resources and their influence on marine bird communities, see Eckert et al. (2006) and Renner et al. (2012).

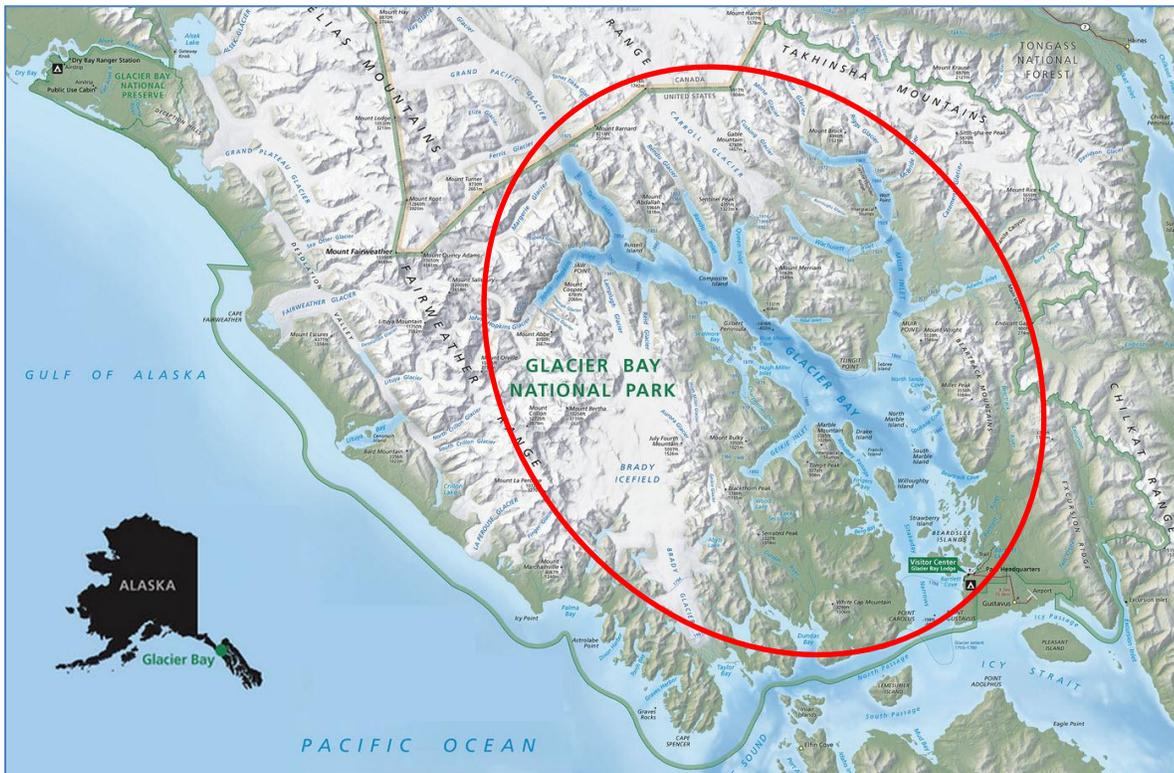


Figure 1.1. Map of Glacier Bay National Park and Preserve. Within the red circle lies Glacier Bay proper, which includes waters north of Icy Strait. See Figure 2.1 for details of the survey area and transects.

1.4 Rationale for Monitoring

The KIMU and related Marine Predators Vital Signs were selected as priority monitoring programs based on their ecological importance, conservation status, and resource management significance. Collectively, life histories of species included in these two Vital Signs will integrate a range of temporal, spatial, and ecologically-distinct habitats. As a summer resident and marine pursuit forager that nests on land, KIMU play an important role as integrators of variation in marine and terrestrial ecosystems and directly relate to the conceptual ecological models in the SEAN Monitoring Plan (Moynahan et al. 2008). Sea otters (*Enhydra lutris*) are currently the next highest priority for marine predator monitoring in GLBA, given their unique ecological niche as sub-tidal benthic foragers, rapidly expanding population, and management relevance. Black-legged kittiwakes (*Rissa tridactyla*), year-round residents and colonial-nesting surface foragers, are also receiving consideration for monitoring (Brinkman et al. 2013).

KIMU are the subject of considerable conservation concern, as many KIMU breeding-season aggregations have exhibited steep declines over the past decades (USFWS 2013). Glacier Bay supports a breeding population of global significance: the ~13,000 KIMU inhabiting Glacier Bay during July 2009-2012 (Hoekman et al. 2011a, b; 2013 a, b) encompass perhaps the largest known breeding season population and likely a substantial fraction of the global population (USFWS 2013). Many KIMU summering in GLBA likely are breeding adults, with radio-telemetry identifying probable nesting locations within GLBA's uplands in 2011 (T. Marcella, unpublished data).

Given this conservation context, KIMU monitoring is a priority for GLBA and SEAN. With jurisdiction over its marine waters, GLBA manages all activity for vessels ranging from small private pleasure boats to cruise

ships. Research in GLBA has indicated energetic costs to murrelets incurred by vessel disturbance could meaningfully depress survival and reproduction (Agness et al. 2008, 2013). The nexus of potential for population-level effects of vessel traffic on KIMU with observed range-wide population declines (see Marine Ornithology 2011 volume 39(1); USFWS 2013) has important implications for management of park visitation by GLBA.

1.5 Prior Murrelet Surveys in Glacier Bay

Multiple sampling challenges and local population-specific research questions have prompted several agencies to develop differing protocols for monitoring the status and spatial distribution of KIMU populations. KIMU are difficult to enumerate due to small size, cryptic coloration, patchy spatial distributions within remote and rugged areas, and co-occurrence with MAMU, a more abundant congener with similar morphology. Eight prior surveys in and near Glacier Bay (Table 1.1) over nearly 20 years employed differing sampling and analytical methods. Differences have complicated comparison of population estimates, and uncertainty concerning population status and trend remains (Hoekman et al. 2011b, c; Piatt et al. 2011; USFWS 2013; Kirchhoff et al. In Press). After examining prior approaches and considering costs and benefits of implementing novel approaches, SEAN undertook a multi-year effort to build on prior efforts and develop a monitoring protocol enhancing assessment of population status, trend, and spatial distribution for KIMU in Glacier Bay.

Table 1.1. Summary of prior and ongoing surveys for monitoring KIMU populations in or near Glacier Bay (after Hoekman et al. 2011b, Kirchhoff 2011).

Survey year(s)	Reference(s)	Transect layout (sampling design)
1991	Piatt et al. 1991	Shoreline and crossing (opportunistic)
1993	Lindell 2005	Crossing zigzag (convenience)
1999-2003	Drew et al. 2008	Shoreline and perpendicular to shore (systematic)
2007	Kirchhoff 2008	Perpendicular to shore (random)
2008	Piatt et al. 2011	Shoreline and perpendicular to shore (systematic)
2009	Kirchhoff et al. 2010	Crossing zigzag (convenience)
2010	Kirchhoff and Lindell 2011	Crossing zigzag (convenience)
2009-2012; continuing	Hoekman et al. 2011a, b; 2013a, b; this protocol	Perpendicular to shore and zigzag (random stratified)

SEAN conducted KIMU population surveys in 2009 and 2010 (Hoekman et al. 2011a, b) with a focus on tailoring field and analytic methods to the study area and species. Objectives of pilot surveys in 2009 were to implement boat-based line transect surveys and test critical assumptions and uncertainties of these methods. Based on challenges to effective monitoring identified from our 2009 surveys and other prior surveys, we

refined sampling and analytic methods for 2010 (described in section 2 below) to form the basis for this protocol. Our 2009 and 2010 abundance estimates for KIMU in Glacier Bay were similar to estimates from concurrent surveys using similar methods but were much higher than prior estimates from surveys using dissimilar methods. These initial two years of NPS sampling resulted in a finalized design (Hoekman et al. 2011c) that is the basis for this protocol.

1.6 Program Objectives

Starting in 2009, SEAN undertook a two-year process to develop and implement boat-based, line transect surveys to estimate status of the on-water KIMU population (and secondarily MAMU) within Glacier Bay during the breeding season. Our objectives were to:

- Design and implement a monitoring program providing $\geq 80\%$ statistical power ($\alpha=0.05$) to detect a 33% population decline over 15 years.
- Estimate population status annually.
- Periodically (~6-year intervals) estimate population trend from period-of-record annual estimates of population status.
- Characterize annual variability in spatial distributions of populations.

2.0 Study Design

Our primary objective of achieving sufficient statistical power to detect decline in KIMU abundance guided our study design process. Results from our pilot and other prior surveys facilitated identification of challenges to effective monitoring inherent to our study system (Table 2.1). Glacier Bay’s convoluted topography (Figure 2.1) complicated obtaining a representative sample and defining survey transects with desired shape, length, and orientation. At-sea surveys must also accommodate difficulty in detecting murrelets (Kissling et al. 2007, Kirchoff 2008, Lukacs et al. 2010, Hoekman et al. 2011a, b, c) and in reliably distinguishing between species (Hoekman et al. 2011a, b, c, Kirchoff 2011). Finally, prior results revealed large spatial and temporal variability in populations (Romano et al. 2007, Drew et al. 2008, Kirchoff et al. 2010), which can strongly diminish capacity to assess population status and trend.

We evaluated numerous alternative sampling and analytic strategies to address these challenges, an effort that included field-testing survey equipment and methods, developing appropriate analytic methods, identifying beneficial sampling designs, and assessing capacity to meet objectives (Table 2.1). Key elements of our design included:

- Line transect surveys on linear or zigzag transects 4-8 km in length and oriented from shore-to-shore.
- Analytic methods accommodating incomplete detection/identification of murrelets and large spatial variation in their densities.
- An augmented serially alternating panel design with transects selected using a combination of Generalized Random Tessellation Stratified (GRTS) and unequal probability sampling, thus providing a spatially-balanced sample with sampling intensity positively correlated with expected KIMU densities.

Table 2.1. Challenges to effective monitoring of population status and trend for KIMU in Glacier Bay. Consequences indicate the primary negative effects; design remedies summarize elements mitigating consequences.

Sampling Challenges	Consequences	Design Remedies
Incomplete detection of murrelets	Negative bias in population status	Line transect surveys 2 survey observers Estimating detection probability near transect center line
Incomplete species identification	Negative bias in population status	Estimator allocates unidentified murrelets
Complex topography	Poor, inconsistent sampling coverage	Linear or zigzag transects
Gradient in density relative to shore	Decreased precision in estimates of population status/trend	Transects oriented across gradient
High spatial variation in density	Decreased precision in estimates of population status/trend	GRTS sampling design Unequal probability sampling Local variance estimator Transect length 4-8 km No within-year replication
High annual variation in abundance	Decreased precision in estimates of population trend	Annual surveys
Simultaneous estimation of population status/trend	Opposing optimal revisit designs	Augmented serially alternating panel design

2.1 Methods: Testing and Development

Initial population surveys for murrelets in Glacier Bay (Lindell 2005, Romano et al. 2007, Drew et al. 2008, Drew and Piatt 2008) used then-standard strip transect survey methods (Gould and Forsell 1989, Agler et al. 1998), which assume complete detection of murrelets within the survey strip (Williams et al. 2002). However, this assumption was not supported for these small, cryptic diving birds (Kissling et al. 2007, Kirchhoff 2008, Lukacs et al. 2010, Hoekman et al. 2011a, b, c), and we employed more recent line transect methods allowing estimation of detection probability (Buckland et al. 2001). During the July 2009 pilot field season, we tested efficacy of boat-based line transect surveys (Hoekman et al. 2011a, c) and tailored survey methods to our study system. A field experiment revealed the critical assumption of complete detection near the transect line was not met, so we adjusted analytic methods to account for this discrepancy and avoid negative bias in estimates of detection probability and abundance (Hoekman et al. 2011c).

Where KIMU and MAMU coexist, rates of species identification (the proportion classified to species) during surveys have varied widely (Agler et al. 1998, Lindell 2005, Drew et al. 2008, Kirchhoff 2008, Kirchhoff et al. 2010, Kuletz et al. 2011). Recent studies have incorporated unidentified murrelets into population estimates (Arimitsu et al. 2011, Kissling et al. 2011, Kuletz et al. 2011), but some prior studies did not, resulting in large and variable negative bias in estimates (Hoekman et al. 2011c). We extended distance sampling methods to incorporate unidentified murrelets in species-specific population estimates by assuming that the proportion of each species in the identified and unidentified samples was the same (Hoekman et al. 2011c). Additionally, results from pilot surveys demonstrated two observers had substantially higher detection probabilities and species identification rates than one, resulting in more precise and reliable population estimates.

For details on experimental results from pilot studies and analytic methods see Appendix A.

2.2 Site Selection

Our survey area covers 1,170 km² of waters within Glacier Bay, excluding some non-motorized waters and waters too small or shallow to allow safe passage (Figure 2.1). A primary concern for our survey design was large spatial variation in murrelet densities observed within Glacier Bay, presumably partly in response to ephemeral concentrations of food, water depth, and distance to shoreline (Zamon 2003, Arimitsu et al. 2007, Drew et al. 2008, Kirchhoff et al. 2010, Renner et al. 2012). Our initial surveys (Hoekman et al. 2011a, b) confirmed that variance in encounter rates (groups detected/km) among transects dominated overall variance in estimates of population status; therefore, reducing the magnitude and consequences of variability among transects was paramount to maximizing precision.

Transect placement was further complicated by complex topography of Glacier Bay, which hindered obtaining representative sampling coverage and placing transects of suitable length, shape, and orientation. Transects paralleling coastlines have been used to sample nearshore waters (Piatt et al. 1991, Drew et al. 2008). However, such transects parallel a strong gradient in KIMU density relative to distance from shore and are difficult to precisely replicate along convoluted shorelines, leading to inconsistent coverage and increased deleterious effects of spatial variation in densities (Kirchhoff 2008, 2011). Instead, we preferred linear or zigzag transects crossing from shore-to-shore, because these could be precisely replicated, provided reasonably representative coverage across water depths, and followed the preferred procedure of orienting

transects across a density gradient to minimize variation among transects (Buckland et al. 2001, Fewster and Buckland 2004).

Completing surveys over a short (~two week) period was imperative to sampling relatively closed populations, and our total annual sampling effort (~250 km) was constrained by the amount that could be sustained by one crew and boat in face of limitations imposed by environmental conditions, logistics, etc. Because the number of transects would be inversely proportional to their average length, optimal length involved a trade-off between maximizing sample size with shorter transects versus reduced variance in encounter rates among longer transects. Based on a pattern of rapidly diminishing reductions in variance among transects with increasing length, Drew et al. (2008) recommended transects of 4-8 km. Likewise, our results from 2009 surveys demonstrated transects <3 km made a disproportionately large contribution to overall variance of population estimates (Hoekman et al. 2011a), and we targeted transects of 4-8 km. To achieve desired lengths, most linear transects ran shore-to-shore, with some transects traversing the widest portion of Glacier Bay split into two. In narrow fjords, shore-to-shore transects perpendicular to shoreline would be below desired lengths (Hoekman et al. 2011a). Therefore, in waters <2.5 km in width, we employed zigzag transects to achieve desired lengths while still retaining benefits accrued from a linear, shore-to-shore transect layout.

Prior studies also revealed large spatial and temporal variation in population densities (Romano et al. 2007, Drew et al. 2008, Kirchhoff et al. 2010), which will tend to decrease precision of estimates of population status and trend. However, appropriate sampling design and analytic methods can minimize loss of precision (Urquhart and Kincaid 1999, Larsen et al. 2001).

Where strong spatial density gradients exist—as with KIMU populations in Glacier Bay (Drew et al. 2008, Kirchhoff et al. 2010, Hoekman et al. 2011a, b)—simple random sampling is less efficient than spatially-balanced sampling designs, which minimize over-representing high- or low-density areas (Stevens and Olsen 2004, Fewster et al. 2009). However, commonly used spatially-balanced sampling designs (e.g., systematic designs) are not fully random, which typically leads to substantial loss of efficiency (Fewster et al. 2009). We chose a GRTS sampling design to provide a spatially-balanced yet random sample coupled with an efficient variance estimator (Stevens and Olsen 2004).

To increase precision of abundance estimates, sampling intensity often is allocated proportional to density (Cochran 1977, Thompson et al. 1998, Williams et al. 2002). Geographic stratification is a common type of sampling allocation where sampling intensity is identical within pre-determined geographic strata. In 2009, we delineated high- and low-density strata based on prior densities of KIMU, and doubled sampling intensity in high-density strata (Hoekman et al. 2011a). This approach yielded moderate increases in precision, but unpredictable inter-annual variation in KIMU distributions (Drew et al. 2008, Kirchhoff et al. 2010, Hoekman et al. 2011a, b) may limit benefits of geographic pre-stratification.

Our final design implemented unequal probability sampling and geographic post-stratification. Using unequal probability sampling (Stevens and Olsen 2004), we adjusted sampling inclusion probability so that a doubling of expected density of KIMU provided a 50% increase in probability of an area being sampled. We also incorporated a local variance estimator (Stevens and Olsen 2003), which uses post-stratification of data to take advantage of observed spatial gradients to enhance precision. Unlike geographic pre-stratification, which relies on consistency between expected and actual densities, post-stratification does not require pre-

defined strata. For data with strong spatial trends, post-stratification can yield substantial increases in efficiency relative to un- or poorly-stratified data (Stevens and Olsen 2003, Fewster et al 2009, Fewster 2011).

To obtain a sample of transects of specified shape and orientation, we generated a large, systematic sample of transects across the study area and used Program S-DRAW (version 1.0, authored by Trent McDonald, WEST, Inc., available at <http://www.west-inc.com>) to select a GRTS sample with specified inclusion probabilities.

For further detail on placement and selection of transects, see sections B.3-B.7 in Appendix B.

2.3 Sampling Frequency and Replication

Optimal sampling frequency and replication are closely associated with population variability and monitoring objectives. In general, ability to detect population trend is strongly inversely related to the magnitude of population variability (Gerrodette 1987, Gibbs et al. 1998, Urquhart and Kincaid 1999). Additionally, trend detection and optimal sampling strategies are affected by the structure of variation, which can be decomposed into four components (Urquhart et al. 1998, Larsen et al. 2001, Kincaid et al. 2004): coherent annual variation (annual variation consistent across transects), ephemeral annual variation (annual variation differing among transects), within-period variation (variation at a transect within a sampling period), and spatial variation (consistent variation among transects). Glacier Bay murrelet populations have shown substantial spatial and temporal variability, but reliable estimates of variation components are unavailable, because estimates have been relatively few and imprecise and because differences in methods among surveys impede comparisons (Table 1.1; Hoekman et al. 2011b, c). However, some broad patterns guided our design process.

The magnitude of coherent annual variation is strongly inversely related to ability to monitor trend (Urquhart et al. 1998, Urquhart and Kincaid 1999), and this variation typically overwhelms other components of variation and presents the greatest impediment to ecological monitoring (Gibbs et al. 1998, Kincaid et al. 2004). Accruing a longer time series is the only effective remedy, as returns quickly diminish from design decisions such as adding sampling units or replication within a sampling period (Urquhart et al. 1998, Larsen et al. 2001). Preliminary estimates, although imprecise, have suggested large annual variability in Glacier Bay KIMU populations (see section 2.4), and we reasoned sampling annually would be critical to maximizing trend detection capability.

Murrelet populations in Glacier Bay have demonstrated substantial ephemeral annual variation and spatial variation (Drew et al. 2008, Kirchhoff et al. 2010), with more limited evidence for significant within-period variation (Romano et al. 2007, Kirchhoff 2008). While replicating transects within a sampling period decreases loss of precision from within-period variation, adding transects reduces effects of both within-period and ephemeral annual variation (Larsen et al. 2001). Hence, given limited sampling effort, we preferred visiting more transects each year to replicating transects within a survey.

Our objectives of monitoring population status and trend favored opposing revisit designs. Negative effects of spatial variation on estimating trend can be removed by revisiting sampling units at each sampling period (Urquhart et al. 1998). In contrast, assessment of status benefits from increasing total sampling units (Skalski 1990, McDonald 2003). Rotating panel designs can successfully balance these objectives, as little efficiency

is lost in assessing status and trend relative to designs optimal for either one (Urquhart et al. 1998, Breidt and Fuller 1999, Urquhart and Kincaid 1999). We opted for 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 (Figure 2.1). Our alternating panels were comprised of transects with low expected densities of KIMU. This approach allowed annual coverage of areas with expected high KIMU densities as well as increased coverage in areas where sampling was sparse, which will enhance ability to assess change in spatial distributions of populations over time.

For further detail on our revisit design, see section B.7 in Appendix B.

2.4 Capacity to Detect Population Change

Estimates from prior surveys provide information about population variability that can be useful for conducting power analyses to guide survey design and to assess capacity to meet monitoring objectives (Taylor and Gerrodette 1993, Steidl et al. 1997). Variation in population estimates among surveys is a key uncertainty, as increased variability dramatically decreases trend detection capability (Larsen et al. 2001). Variation in estimates combines sampling error and true variation in populations (Link and Nichols 1994, Larsen et al. 2001). Although precision of our population estimates has met or exceeded many prior surveys, our analyses of results of Drew et al. (2008) indicated large uncertainty remained about variability in murrelet populations in Glacier Bay. Power analyses for our monitoring program indicated achieving 80% power to detect a 33% KIMU population decline over 15 years was plausible, but highly uncertain, on account of uncertainty about annual variability in KIMU populations. We projected high power to detect shorter, steeper declines (e.g., 50% over ten years). We recommend reassessing population variability and power to achieve monitoring objectives at the first periodic review of this monitoring program.

For further detail on our assessment of capacity to detect population change, see Appendix C.

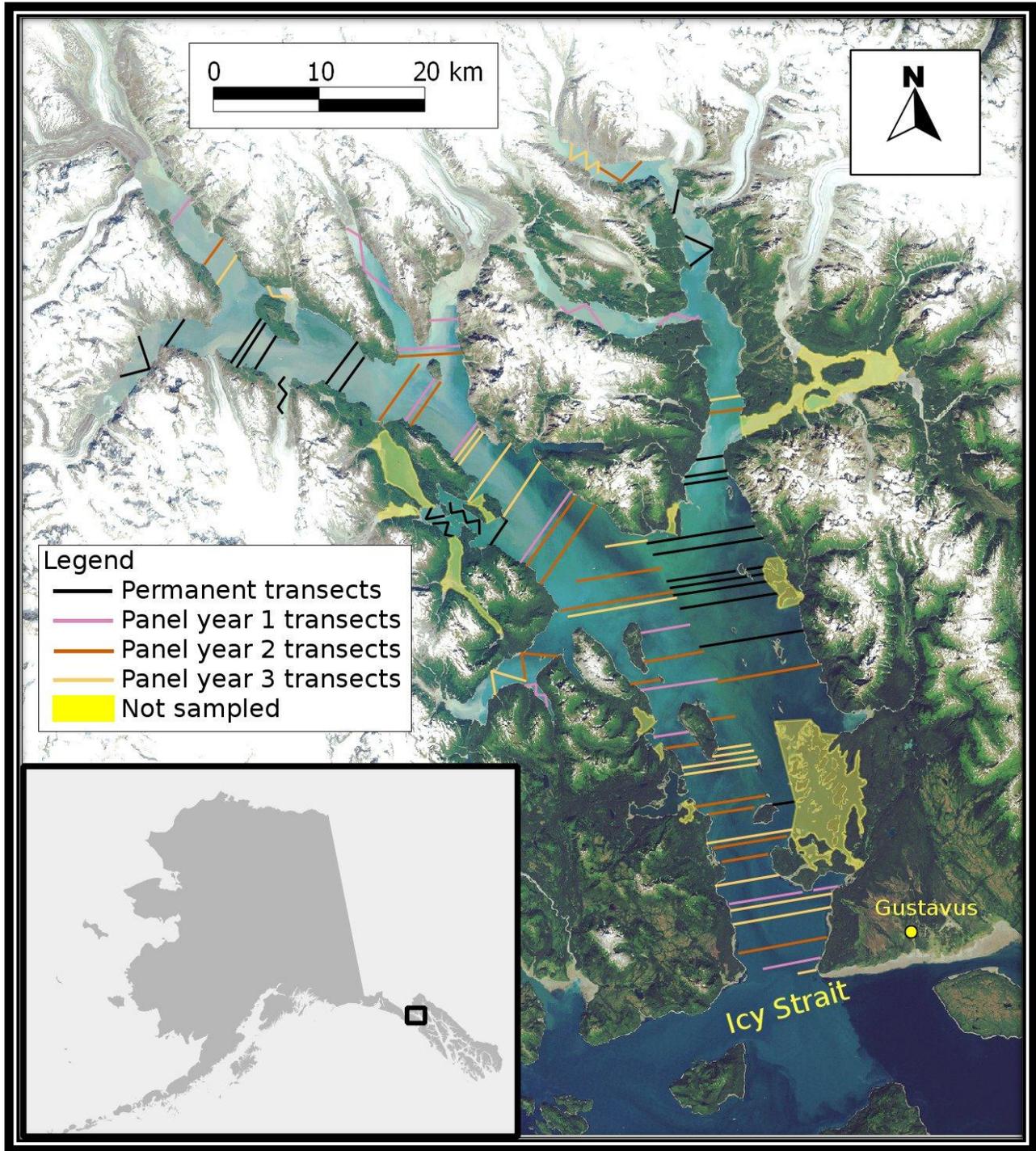


Figure 2.1. Line transect surveys for murrelets cover waters of Glacier Bay (near Gustavus, Alaska) north of Icy Strait, excluding some small or non-motorized areas. Transects are linear or zigzag and typically traverse from shore-to-shore. According to an augmented serially alternating panel design, permanent transects are sampled annually while other panels are sampled on a three year rotation.

3.0 Field Methods

Conducting surveys requires about 2 weeks annually. We survey in early July when KIMU populations peak in Glacier Bay to maximize precision of population estimates (Kissling et al. 2007, Kirchhoff 2011). Full details related to methods, equipment, and training for field operations are presented in SOPs 1–5 and SOP 9. Data collected during at-sea surveys forms the basis for SOP 6, procedures for generating annual data analyses and summaries are detailed in SOPs 7, 11, and 12, and SOP 8 presents recommendations for periodic in-depth program reviews.

3.1 Field Season Preparation

Before the start of field operations in early July, necessary equipment should be on hand and in good working order. Equipment checklists are presented in SOP 1. Equipment needs are detailed relative to the following general categories:

- Boat: In safe operating condition with safety and emergency equipment.
- Observers: Binoculars, radios, angle board, and training materials.
- Data Manager: Laptop computer and necessary software, GPS, data forms.
- Personal gear: Appropriate clothing, camping equipment, and food/food preparation items.

In addition to assembling equipment, time should be allotted for pre-survey training relative to experience and needs of personnel. Prior to data collection, surveying “practice” transects is necessary to verify equipment and personnel are fully functional. SOP 9 details office- and field-based training and assessment procedures to enhance murrelet species identification and distance estimation skills of observers.

Certain scheduling details should be addressed at least two months before field operations. Permissions to enter non-motorized waters and the Johns Hopkins critical habitat area should be updated or extended. Particular attention should be paid to time windows for accessing areas with special travel restrictions. Survey panels and restrictions will differ annually, so careful schedule management will keep surveys within the required time windows and minimize travel distance.

3.2 Field Operations

Field operations are scheduled annually for the first two to three weeks of July. During calm sea conditions (Beaufort force 2 or lower), boat-based line transect surveys (Buckland et al. 2001) are conducted during daylight hours on transects from selected survey panels for each year. A laptop with the NPTransect software (Appendix F) integrates an external Global Positioning System (GPS) unit with Geographic Information System (GIS) software to provide navigation aids and a tracklog for each transect surveyed. NPTransect also provides the primary means of recording survey observations (locations, numbers, and species classification of murrelets) and characteristics of survey transects (environmental conditions, timing, and observers). Complete details of field operations are provided in SOPs 1-5.

3.2.1 Survey Platform and Personnel

Line transect surveys must be conducted from small boats (~8-10 m) that provide 1) an open platform in the bow for at least 2 observers with a viewing height of ~2.5 m above water, 2) a covered cabin with suitable space and power supplies for data recording equipment, and 3) capability to maintain a relatively constant bearing at ~10 km/h. Currently, suitable vessels include the NPS *R/V Fog Lark* and *R/V Capelin*.

Personnel requirements for surveys include a Boat Pilot, a Data Recorder, and at least one but preferably two or more Observers. These roles typically are filled by the SEAN Program Manager, the SEAN Ecologist, the SEAN Data Manager, and other personnel as needed. GLBA provides staff for tracking float plans associated with field operations, processing permit requests, and boats maintenance. See SOP 1 for further details.

3.2.2 Data Acquisition

Real-time GPS locations and GIS “moving maps” displayed by NPTransect guide navigation along waypoints defining survey transects. Maximum survey speed of 10 km/h may be reduced when encountering high densities of murrelets. For all groups of murrelets initially detected on the water, Observers record count, species class (KIMU, MAMU, or unidentified), and estimates of distance and angle from the boat. Observations are communicated via radio to the Data Recorder, who concurrently enters these data into a spatial database using NPTransect. NPTransect records a date/time/location stamp for each observation as well as periodic stamps comprising the boat's tracklog. Environmental conditions are continuously recorded during surveys by the Data Recorder. The spatial database provides real-time display of the tracklog and observed groups on a moving map and permits editing of observation data. The Data Recorder also uses paper records and waypoint locations from the GPS to make notes, correct errors, and record data in case of computer failure. Details of survey transects and data acquisition are presented in SOPs 1, 2, and 5.

3.2.3 In-field Data Management

Survey data are backed up as frequently as practical during field operations. Multiple copies of data are stored on separate laptop computers as well as jump drives both on vessels and at land locations. Output from survey data acquisition consists of spatial databases and data recorded on paper data forms. Preliminary inspection should be conducted during and shortly after data acquisition to identify potential errors in data, equipment failures, or other flaws. In addition to viewing spatial data in ArcMobile GIS software, spreadsheet and text editor software will also be useful for visualizing and summarizing data. For complete details concerning survey data management in the field, see SOP 1. Data management for distance estimation calibration procedures (see section 5.2) are described in SOP 9.

3.2.3 Post-survey Operations

After completing field operations, the Data Manager performs preliminary error-checking procedures for the ‘raw observations’ database, seeking clarification about potential errors from involved personnel as needed. Corrections are applied to a revised ‘corrected observations’ database. Field data forms are archived by scanning to Adobe .pdf file format (hereafter “PDF”). Waypoints collected directly from the GPS by the Data Manager during field operations are error-checked and archived in a spreadsheet file. All databases and archives are uploaded to the SEAN network. Full details of data handling are presented in SOPs 2 through 6.

All field equipment are cleaned, repaired or replaced, and properly stored. Boats used during surveys are given proper cleaning and maintenance. Safety and emergency equipment are cleaned, inspected, and stored.

4.0 Data Handling, Analysis, and Reporting

This chapter describes the general approaches to generating, maintaining, and disseminating products of this monitoring protocol. Detailed procedures are provided in product-specific SOPs as referenced in Table 4.1. Detailed product definitions are in Appendix H.

4.1 Overview of Information Architecture

Data generated by the KIMU monitoring program are managed according to the standard methods used by all SEAN programs, as described in the SEAN Data Management Plan (Johnson and Moynahan 2008). The model from which these methods were derived is illustrated in Figure 4.1.

Dissemination of all data is done electronically from SEAN and partner web sites. Certain reports are also published by NPS in Natural Resource Technical Report (NRTR), Natural Resource Report (NRR), and Natural Resource Data Series (NRDS) form.

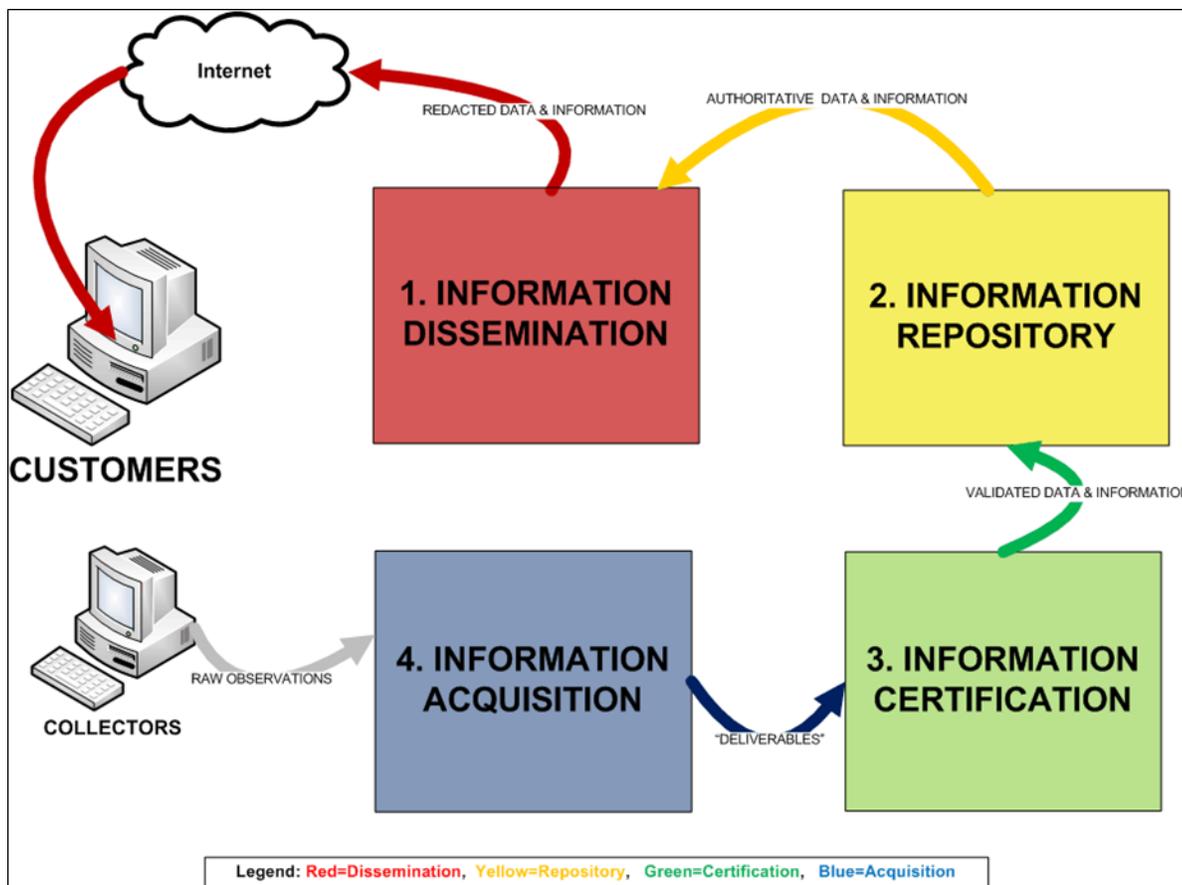


Figure 4.1. The SEAN Core Functional Model overview. Dissemination services (red) provide all deliverables to all customers using Internet web servers. Repositories (yellow) store the certified inventory and monitoring products called for in the protocols. Certification processes (green) assure repositories have the highest quality data and that sensitive items are restricted to authorized users. Data acquisition processes (blue) led by park staff and cooperators include a wide array of tasks, ranging from collecting raw data to composing reports on long-term trends. The KIMU data management facility was designed in the sequence shown in order to provide the desired outcome.

4.2 Overview of Data Products

The KIMU monitoring program creates and maintains eleven specific data products (known as “deliverables”) for customers. Each deliverable is disseminated directly from the SEAN web site, the single authoritative source for these deliverables. Copies of selected deliverables are also available at the agency’s Integrated Resource Management Application (IRMA) Portal, which may be searched on the web at <http://irma.nps.gov>. In the event that a data product obtained from outside the SEAN web site ever diverges from the values disseminated by SEAN, the SEAN version should be considered authoritative.

This program’s deliverables are summarized in Table 4.1 and technically defined in Appendix H. Accompanying each definition is a data flow diagram illustrating from where underlying data come, what processes are applied to them, where they are stored, and who is responsible for managing each of them (Appendix H, Figures H.1–H.11).

SOPs present the detailed steps for creating each deliverable. Table 4.1 includes a column referencing the appropriate SOP to use in building each one.

KM_A: Target transects geospatially displays the survey transects used by this program. Transects employ a serially augmented panel design, where one panel (set of transects) is sampled annually and three panels are sampled over a three year cycle. The product is provided in three formats: images, GIS feature classes, and tables.

KM_B: Field data Observer forms are written up by the Data Recorder during the course of each survey transect. The primary purpose of the form is to note corrections to recently recorded observations. Due to the hectic pace of recording at certain times, it is not always practical to stop data entry in order to edit observations. In such cases the corrections are written on the form and applied to the data after completing the transect. The forms also serve as backup to immediate laptop entry when computer failures are encountered. Finally, the form is used to record comments regarding exceptional circumstances encountered. KM_B is a PDF file of all scanned observer form images for each particular year.

KM_C: Raw observations contain trackpoints along each actual transect as well as observations of murrelet groups that include location, time, species classification, size of group, angle from boat, and distance. They are recorded on laptop using software developed for the purpose. Each transect record is stored in a laptop “mobile cache” which is subsequently merged into a proprietary ESRI “file geodatabase” covering the year of interest. Raw observations also reflect field corrections noted on observer forms that are edited into the data stream in the field directly following completion of a transect. The geodatabase file set for the year is packaged into a single file using the .zip (hereafter “ZIP”) archive file format as KM_C.

KM_D: Corrected observations are based on the KM_C file geodatabase for the year. The data receive corrections from post-field quality control processes. Corrections may be based on notes found on KM_B observer forms, obvious transcription errors, recollections of Observers, and judgment of scientists. An accompanying flat .csv (comma separated value, hereafter “CSV”) format file of observation details is generated from the geodatabase. The geodatabase and CSV are archived in a ZIP file and distributed as KM_D.

KM_E: Cumulative observation database is a collection made from the content of the KM_D corrected observations and maintained using a Structured Query Language (SQL) database management system. Certain derived information, including various statistical estimates, are also pre-calculated and stored in the database. Because a consistent methodology is employed by this monitoring program, a consistent single database (i.e., one that does not alter in structure or meaning by year) is available through the web.

KM_F: Annual report is a PDF file created each year that documents the survey program's operations, exceptions, and working estimates. Tables and figures are included for species-specific estimates of density/abundance, spatial distribution of observations for each species, and detection function details. The report also recommends changes to improve the protocol and standard operation procedures.

KM_G: Six-year review is a PDF file that provides more in-depth analyses covering a period of years. These include analyses of population status, trend, and spatial distribution; assessment of model assumptions and protocol performance; and other appropriate studies.

KM_H: Protocol is this document that defines the KIMU monitoring program. Because every data product is defined by a particular version of the protocol and is so stamped internally where possible, the protocol is treated as a deliverable under formal data management. The collection of protocols is formally versioned and kept available so researchers may be able to find out the exact nature of information products created at any time over the life of the program.

KM_I: Waypoints is a single file recorded on GPS that covers the annual field work. It contains the exact endpoints of transects for that year to use in case of main navigation equipment faults. It also contains locations recorded during surveys that mark exceptional circumstances, such as interruption of transects or when computer failure has forced manual recording of observations. One CSV file is made per year.

KM_J: Detection function is a ZIP file containing output from Program DISTANCE. It details the detection function, detection probability, and related items.

KM_K: Density and abundance estimates by species, along with associated parameters, are kept in a cumulative table over the life of the program. The table is available for download from the web site as an ASCII comma delimited file (CSV).

Table 4.1. The SEAN data deliverables provided by this monitoring program.

Deliverable Title	Description	Disseminated to Customers as	Frequency Produced	Ultimately Responsible	Defining SOP
KM_A: Target transects	Map showing transect names and target locations for all years, plus table defining characteristics of each transect.	Part A: GIS shapefile and JPEG file archived in a ZIP file. Part B: downloadable CSV.	Once for each protocol version.	Protocol Revision Lead	10
KM_B: Field data observer forms	Two-sided color scans of the original field recording sheets used by Observers during field season.	PDF file.	Once per year after all field work has been completed for the season.	Project Lead	2
KM_C: Raw observations	Result of field data collection program containing all transects, trackpoints and observations used in a particular year.	ESRI file geodatabase archived in a ZIP file.	Annually.	Data Manager	3
KM_D: Corrected observations	KM_C geodatabase for a particular year with quality control corrections applied from KM_B forms and other sources.	ESRI file geodatabase plus a CSV format ASCII file all archived in a ZIP file	Annually.	Data Manager	4
KM_E: Cumulative observation database	Best available trackpoints, observations, and derived information obtained for all years, with certain derivable values pre-calculated.	Downloadable on demand to user as a CSV file via browser.	Added to annually, corrected episodically.	Data Manager	6
KM_F: Annual report	Annual report summarizing significant aspects of the year’s operations and data, including preliminary estimates of density and abundance.	PDF file.	Once per year after all subsidiary data products have been certified.	Project Lead	7
KM_G: Six-year review	Report analyzing population trends and reviewing methodologies using data covering a period of years.	PDF file.	Every 6 years.	Project Lead	8
KM_H: Protocol	Protocol document, defining the details of the monitoring program.	PDF file.	As needed.	Program Manager	10
KM_I: Waypoints	Collection of GPS waypoints recorded during the season in order to mark exceptional events.	CSV file.	Annually.	Data Manager	5
KM_J: Detection function	Summary of estimated detection function(s) and details of model selection.	Two ASCII text files and a PNG graphic archived in a ZIP file.	Created annually.	Project Lead	11
KM_K: Abundance estimates	Estimates of species-specific murrelet density and abundance for each survey year.	Downloadable on demand to user as a CSV file via web browser.	Cumulative table updated annually.	Data Manager	12

4.3 Dissemination: Accessing the Data Deliverables

In keeping with SEAN's Data Management Plan (Johnson and Moynahan 2008), customers may access all of the KIMU monitoring program's deliverables directly from SEAN's public web site. The web site also contains useful ancillary information and references to relevant published and gray literature. Figure 4.2 illustrates typical main page content (in order to highlight the links between Table 4.1 content and the web site, Figure 4.2 is annotated with deliverable IDs in blue). Pages also provide access to formal Federal Geographic Data Committee (FGDC) metadata in Extensible Markup Language (XML) format for each specific deliverable type, where appropriate. Figure 4.2 is intended to illustrate content only. The actual layout, graphics, and enterprise links used will follow the latest guidance of the national Inventory and Monitoring (I&M) program. While the dissemination services are publicly available worldwide, the target audiences are NPS resource managers and specialists as well as the broader scientific community.

Selected certified deliverables and their metadata are also installed in NPS's IRMA Data Store for further dissemination (<http://irma.nps.gov/>). Should discrepancies be found between copies of deliverables in IRMA and original SEAN web site products, SEAN is the authoritative source.

In the SEAN model (Figure 4.1), a Project Leader is also a customer. When creating a product based on earlier deliverables (e.g., annual or six-year reports), the Project Leader uses as source material the certified SEAN deliverables from the web; the Project Leader's local work files are not used. This ensures deliverable creation processes only use certified authoritative data and, thereby, are reproducible.

No deliverables of the KIMU monitoring program are currently considered sensitive. Should a future policy revision identify some items as sensitive, they will be sequestered at SEAN and will not be available for general dissemination. Questions regarding existence of sequestered products should be directed to the Data Manager through the "Contact Information" link of the web site.

The figure displays three screenshots of the 'Kittlitz's Murrelet Monitoring' website, each showing a different deliverable reference highlighted with a blue box and an arrow pointing to the corresponding menu item.

- Top Screenshot (KM_H):** The 'Program' tab is selected. The 'Protocols' menu item is highlighted with a blue box labeled 'KM_H'. The main content area shows the 'Protocol' deliverable (KM_H), including an overview and a text description of the protocol version.
- Middle Screenshot (KM_F and KM_G):** The 'Program' tab is selected. The 'Annual / Other Reports' menu item is highlighted with a blue box labeled 'KM_F', and the 'Related NPS Data Store References' menu item is highlighted with a blue box labeled 'KM_G'. The main content area shows 'Annual Reports (KM_F)' with two references from 2011.
- Bottom Screenshot (KM_A through KM_I):** The 'Program' tab is selected. The 'Deliverables' menu item is highlighted with a blue box labeled 'KM_A'. The main content area shows 'Query Abundance Estimates' (Deliverable KM_K) with a search filter interface. On the left side of this screenshot, a vertical list of blue boxes labeled 'KM_A' through 'KM_I' has arrows pointing to various menu items: 'Target Transects' (KM_A), 'Field Data Observer Forms' (KM_B), 'Raw Observations' (KM_C), 'Corrected Observations' (KM_D), 'Query Observation Database' (KM_E), 'Detection Function' (KM_J), 'Query Abundance Estimates' (KM_K), 'Waypoints' (KM_I), and 'Toolbox'.

Figure 4.2. Deliverable references (see Table 4.1) located on the KIMU monitoring program's website.

4.4 Repository: Data Archiving

KIMU monitoring program data are maintained in SEAN's Auxiliary Repository on equipment located in the SEAN office in Juneau, Alaska. Parts of the SEAN Data Management Plan detail the Juneau backup and restore mechanism (Johnson and Moynahan 2008: SOP 204 – Backup and Restore Routines; SOP 1101 – Network Archiving Process), and Chapter 11 of that document covers SEAN's philosophy of records management.

Content of the Auxiliary Repository is also mirrored at the production web site and database facilities of the NPS Natural Resource Stewardship and Science Directorate (NRSS) in Fort Collins, Colorado, from which it is publicly disseminated. The NRSS uses enterprise-level business continuity processes to maintain their mirror of SEAN's repository. In the event of catastrophe at one site, the original data may be restored from the other.

Certain data are maintained in SEAN's SQL Server monitoring database. There is one monolithic database used to contain all vital sign monitoring. An authoritative version is physically located in Juneau, and a mirror is kept in Colorado by NRSS. The mirror database is employed by the mirror web site. An explanation of the SQL Server objects used in KIMU monitoring is provided in Appendix G.

4.5 Deliverable Validation and Certification

Each deliverable goes through rigorous validation processes to ensure it meets mandatory quality control criteria. After a submitted product meets all mandatory criteria, the originator reviews the final version and, if completely satisfied, certifies it. Once certified, the Data Manager installs the deliverable in the repository and ensures it is properly accessible from the dissemination web site. The SEAN Data Management Plan describes the approach to validation and certification (Johnson and Moynahan 2008, section 6.4 and SOP 601 – Procedures for Certifying Project Data).

Appendix H explicitly defines the set of mandatory and optional validation criteria for every deliverable in the KIMU monitoring program.

Certification requires orchestrating a set of tasks between the Project Leader and Data Manager (generically depicted in Figure 4.3). For each deliverable, these tasks are detailed in their respective SOPs. Specific interactions between Project Leader and Data Manager are graphically illustrated for each deliverable in the data flow diagrams included in Appendix H.

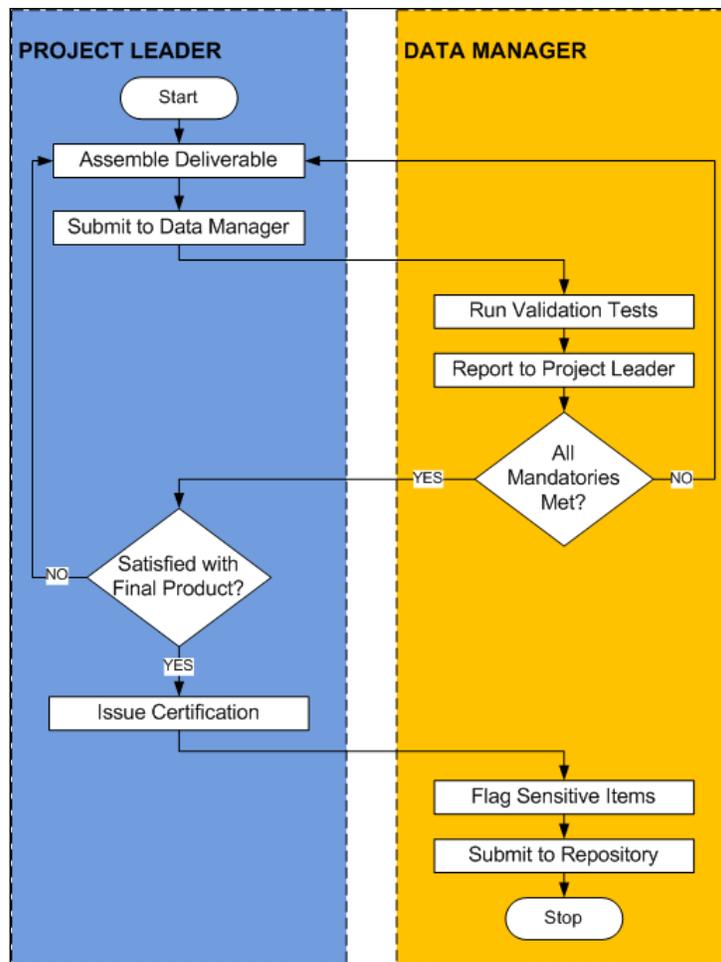


Figure 4.3 Sequence of tasks and staff responsibilities used in the SEAN certification process.

4.6 Data Acquisition: Scheduling Deliverable Production

A set of prerequisites must be completed before certain deliverables can be generated. That is, creating some deliverables may be dependent on prior certification of other deliverables, which, in turn, may have their own dependencies. Table 4.2 illustrates the typical order used in creating the products. Due to the numerous circumstances and exceptions one may encounter while operating the monitoring program, it may become necessary to revise the order of execution ad hoc. Table 4.2 is only an example; the Project Leader may identify acceptable variations. Substantial permanent variations should be formalized in future protocol revisions (SOP 10).

Table 4.2. Typical order of deliverable generation. Some variations on the order are possible.

Deliverable	Comment
KM_H: Protocol	When a new protocol is required, it is imperative it be complete in advance of field work for the season.
KM_A: Target transects	The transect maps, which include a particular panel specific to a season, must be defined in advance of heading into the field. In particular, the certified version must be installed in the data collection application on the laptop which will be taken into the field.
KM_B: Field data observer forms	The paper forms are complete immediately following the fieldwork. They may be scanned and validated at once.
KM_C: Raw observations	The raw observation package is available immediately at the close of fieldwork.
KM_I: Waypoints	The complete waypoint file is available immediately at the close of fieldwork.
KM_D: Corrected observations	Certified KM_B and KM_C are prerequisites to creating this product. It is possible KM_I may also contribute to the content.
KM_E: Cumulative observation database	The basis for this is the certified KM_D for the year. It is particularly important KM_D be fully certified before applying updates to the observation database as it forms the basis of other deliverables.
KM_J: Detection function	KM_J requires a certified KM_E for the year.
KM_K: Abundance estimates	KM_K requires a certified KM_J for the year.
KM_F: Annual report	This annual report can only be composed after all the preceding products have been certified.
KM_G: Six-year review	Typically one informs this with all the KM_F annual reports for the years of interest as well as the KM_E, KM_J, and KM_K deliverables.

4.7 Managing the Production Environment

To provide users of the Internet access to I&M products, content must be housed on “production” file servers, database servers, and web servers. These are currently physically located in Colorado. Only fully-vetted, permanent items are allowed in the production environment. SEAN maintains its own environments in order to prepare content for production. These are known as the Development and Integration environments. They reside on their own servers located at the SEAN offices.

The technical details to observe in preparing program data products and installing them in production are addressed in SOP 13.

4.8 Metadata Maintenance

The Data Manager is responsible for maintaining FGDC-compliant metadata for each tabular deliverable. SEAN stores metadata as XML format files and serves them on the SEAN webpage alongside the deliverables they describe. SEAN uses NPS Metadata Editor and the NPS_Basic_Edit style sheet for basic entry. Where data fields exist, SEAN extends the basic metadata by providing the Entity_and_Attribute_Information section. Metadata considerations are further addressed in Chapter 8 of the SEAN Data Management Plan (Johnson and Moynahan 2008).

5.0 Roles and Responsibilities

Personnel roles and responsibilities are split into office and field components. Primary office roles are Project Leader, Ecologist, and Data Manager, and these roles are likely to be filled by different personnel. Primary field roles are Boat Pilot, Observer, and Data Recorder. Roles, responsibilities, and qualifications for office and field roles will be segregated. There is not a strict correspondence between which personnel will fulfill specific office and field roles, and it is both likely and beneficial that individuals may qualify for multiple field roles.

5.1 Boat Pilot Role

The Boat Pilot has two primary responsibilities: 1) safe and efficient transit of the crew to/from the work area each day and 2) to occupy transects as specified in SOP 1. General duties include filing, updating, and closing a daily float plan; ensuring adequate fuel for the trip duration; daily vessel upkeep and maintenance; and compliance with pertinent park regulations. The captain must have current Department of the Interior Motorboat Operator Certification Course (DOI-MOCC) certification and must be certified by the GLBA Boating Committee for operation of the survey vessel.

The Boat Pilot has the ultimate authority for when to begin, suspend, or end work for the day and how to respond to changing environmental conditions and to other vessels encountered while underway. While all crew members are expected to play an active role under the principles of Operational Leadership, the Boat Pilot must be uniquely and simultaneously aware of the state and probable future conditions – mechanical, crew, environmental, and other vessels.

The Boat Pilot must be very familiar not only with the vessel used, but also the GPS equipment, on-transect processes, communication conventions, speed underway, how to approach/begin transects that start at shore or in open water, and how to approach transect end. These procedures are detailed in SOP 1.

5.2 Observer Role

Prior to collecting data on line transect surveys, Observers will develop proficiency in critical skills and procedures through office- and field-based training exercises.

KIMU and MAMU can be difficult to distinguish in the field, but high and accurate rates of identification are critical to reliable population estimates (Kirchhoff 2011, Hoekman et al. 2011c). Reference materials (see SOP 9) highlighting characteristics useful in discriminating between these species are essential to accelerating development of proficiency in identification by novices and maintaining skills of experienced Observers. Prior to surveys, Observers must become proficient in identifying both species through practice under typical survey conditions. Accurate estimation of distances to murrelet groups is also critical for line transect surveys (Buckland et al. 2001) and proficiency should be developed, maintained, and assessed using distance estimation calibration procedures described in SOP 9. Necessary training time prior to each field season will vary. For experienced Observers, two days may be sufficient to refresh skills, while inexperienced Observers may require up to a week.

Observers must develop proficiency in use and maintenance of survey equipment (e.g., handheld radios, binoculars, rangefinders, angle indicator). To optimize survey performance, Observers must develop a clear understanding of key survey protocols relating to assumptions of line transect sampling, detecting murrelet

groups, estimating distance and angle to groups, species classification, and transmitting records to the Data Recorder (see SOP 1). In addition, familiarity with basic function of Program NPTransect (see Appendix F and SOP 1) will benefit data collection. For detailed description of Observer training procedures, see SOP 9.

5.3 Data Recorder Role

The Data Recorder should be competent in configuration, operation, and maintenance of the laptop computers and handheld GPS devices. Data collection requires proficiency in use of Program NPTransect (see Appendix F), procedures for use of paper backup in case of computer failure, and use of GIS, spreadsheet, and text-editing software. The Data Recorder is also responsible for data backup and performing prompt in-field data error-checking and correction (see SOP 1). The Data Recorder typically will also assist with data collection and management for distance estimation calibration procedures (see SOP 9).

5.4 All Field Personnel

Prior to commencing data collection, all personnel fulfilling field survey roles receive group training in addition to role-specific training described above. Safety and emergency response training includes use of boating safety equipment (e.g., flotation devices, deployment of EPIRB and life raft), emergency procedures (e.g., man over board, emergency radio use), and bear safety procedures. If any backcountry camping is anticipated, GLBA requires formal orientation from visitor information center staff.

Field personnel also conduct practice line transect surveys to become proficient in all roles they expect to fulfill and in working cohesively as a group. Practice surveys should be conducted in areas with at least moderate density of each murrelet species and be continued until competence of the survey crew is achieved. Program NPTransect supports one fixed-location practice transect in Bartlett Cove.

6.0 Operational Requirements

6.1 Annual Workload and Field Schedule

The field season includes boat-based surveys of pre-selected transects that are completed by mid-July each year. Including both field training and survey completion, approximately 10-14 field days per year are required for the Boat Pilot, Data Recorder, and one or more Observers. Approximately one week of pre-field time is required to prepare training materials and to assemble gear and provisions. The field effort is scheduled according to the following timeline:

- By late June: field crew prepares and assembles training materials and field gear; Project Lead ensures that the park permit is current or has been issued; Data Manager prepares field laptops, mobile geodatabase, and NPTransect software, and field forms.
- By July 7: Field team arrives at Glacier Bay.
- For the first two days after arrival: field crew conducts annual training or refresher in field methods, data recording, distance estimation, murrelet species identification, and vessel operations.
- Following training: complete survey. Depending on weather, surveys typically require between six and ten days of survey effort.
- Mid-July: be mindful that transects in upper Muir Inlet currently must be completed on or after July 16, when non-motorized restrictions are lifted. Also, the seasonal closure of Johns Hopkins Inlet was extended to July 15 in both 2010 and 2011; assuming the park continues with this extension, transects in that area must also be completed on or later than July 16. If closure extends beyond July 15, an exemption allowing access will need to be issued by GLBA.

Field crews typically work ~10-hour days while completing surveys.

Processing data requires approximately five days by the Project Leader and Data Manager in September. Approximately ten days are required of the Project Leader to assemble the annual report, which typically should be published by November 30 each year.

We strongly recommend development of full redundancy of staff capabilities for field surveys. At least one of the regular Observers should also be able and certified to operate the vessel (typically the *R/V Fog Lark*), and at least one should be fully trained in data collection and backup procedures. Doing so reduces the burden on any one individual and ensures operational continuity in the inevitable instance of schedule conflict, absence, or turnover.

In aggregate, we estimate that the program requires the following personnel resources:

- Boat Pilot: 8-12 days per year
- Field crews (Observers and Data Recorder): 8-12 days per year
- Project Leader (field prep): 5 days per year
- Annual report generation: 10 days per year
- Data management (pre-field and post-processing): 15 days per year
- Six-year report generation: External cooperator via agreement or contract

6.2 Facility and Equipment Needs

- Vessel for conducting research equipped with
 - GPS system
 - Depth sounder
 - Survival suits
 - Float coats
 - Communications (parknet and marine VHF radio)
 - Emergency beacon (EPIRB)
 - General emergency supplies
 - 12v DC power source and DC-to-AC power inverter
 - Forward platform with space for two side-by-side observers, approximately 2-3 feet above sea level (ASL)
- Laptop primary computer and backup computer
- External GPS receiver and proper power and data cables
- External storage (e.g., thumb drives)
- 10x42 waterproof, anti-fog binoculars (3 pair)
- Laser rangefinders (set to meters)
- Angle indicator board and tripod (or cooler/action-packer on which to strap angle board with ratchet straps)
- Floats and dip net for calibrating distance estimation
- Handheld digital park radios (3) for communication from deck to cabin, with spare batteries and charger

6.3 Startup Costs and Budget Considerations

Startup costs have already been borne by SEAN, which funded expert assistance with preliminary data analysis, survey design, protocol development, and completion of the 2009 and 2010 Annual Reports. Through a Cooperative Ecosystem Studies Unit (CESU) Agreement with The University of Alaska-Fairbanks, SEAN has provided approximately \$225,000 from FY08 through FY11.

With survey design and the protocol complete, recurring annual costs are minimal. The continued success of the program depends to a considerable extent on certain in-kind support from GLBA. Specifically, the program requires continued maintenance and fuel support for the *R/V Fog Lark*, including periodic re-powering as part of the GLBA routine vessel maintenance schedule.

Annual costs include SEAN staff time, backcountry travel expenses (approximately \$2,500-\$3,000 for all crew for the entire field effort), and approximately \$1,000 per year in consumable supplies (e.g., batteries) and replacement of broken or lost equipment (e.g., GPS units, radios, binoculars, etc.). Approximately two weeks of park housing will be needed each year or these travel costs would increase considerably.

Depending on the expertise in-house at SEAN, annual data reporting may benefit from contracting an external quantitative ecologist to help in the analysis, presentation, and interpretation of the collected dataset. We expect that 6-year reports will require external expertise from a quantitative ecologist, either through

contract or cooperative agreement. Scope, cost, and procurement method for this assistance will be determined based on needs at the time.

6.4 Protocol Revision Process

This protocol may be updated or revised as new knowledge, technologies, equipment, and methods become available. Revisions will balance the advantages of new techniques with possible disadvantages associated with disrupting data continuity.

All revisions require review for clarity and technical soundness. Small changes to the existing protocol documents—for example formatting, simple clarification of existing content, small changes in the task schedule or project budget, or general updates to information management handling SOPs—may be reviewed in-house by project cooperators and SEAN staff. Changes to data collection, analysis techniques, or sampling design will trigger an external peer review to be coordinated by the Alaska Region I&M Coordinator.

The SEAN Program Manager will periodically poll the Project Leader and Data Manager on the need to initiate a protocol revision cycle. Every effort will be made to ensure that complete, certified protocol revisions are applied at the start of a new sampling year. Exceptions include revisions that would remedy an identified safety deficiency, a significant issue of data quality, or a breakdown in field operations.

The protocol package itself is defined as data deliverable KM_H. Technical details of its construction and revision processes are specified in SOP 10.

7.0 Other Considerations

This protocol describes survey methods designed to meet challenges inherent to our study system. Changes to the protocol might be spurred by advances in survey, technological, or analytic methods or by new ecological information. Here we briefly highlight information gaps, outline scenarios for potential protocol changes, and justify our current sampling design over plausible alternatives.

7.1 Information Gaps and Future Research

Considerable uncertainty remains concerning basic ecology of KIMU and MAMU (Day et al. 1999, USFWS 2013) and their potential implications for population monitoring. Focused research can minimize uncertainties and optimize monitoring. Our survey (see Appendix B) and analytic methods (see Appendix A) mitigated effects of incomplete detection and species identification, but future research could refine models of detection probability, especially near the transect center line, and test assumptions of methods. Because error in species identification is unknown but associated risks are high (Hoekman et al. 2011c, Hodges and Kirchoff 2012), we advocate field experiments assessing magnitude, causes, and consequences of identification error. Improved knowledge of the spatial distribution and structure of our target populations could enhance survey methods and interpretation of results. Large variability in Glacier Bay murrelet populations in part reflects daily movements from within and outside Glacier Bay (Romano et al. 2007, Kirchoff 2008, Drew et al. 2013), and increased knowledge of timing and causes of movement could facilitate improvements to survey (e.g., diurnal timing of surveys) or analytic methods (e.g., models controlling for effects of key environmental variables, such as tidal stage) such as reducing variability among transects, focusing sampling on desired population segments (e.g., summer residents in Glacier Bay, breeding birds, etc.), and enhancing integration with regional population assessments. Additionally, information on inter-annual site fidelity would inform interpretation of population change.

7.2 Possible Improvements and Changes

Advances in methods, changes in survey effort, or issues intrinsic to the monitoring program could result in protocol changes, but implications of potential changes for long-term monitoring should be carefully evaluated. If change in survey effort or allocation of effort is desired (e.g., if changes in population distributions render current allocation inefficient) or if transects become unsuitable for sampling, the GRTS design can accommodate changes to survey panels or allocation of effort (Stevens and Olsen 2004) at the expense of increased analytic complexity. In addition, large annual variation in spatial distributions of population complicates inference about long-term change, and we recommend caution in altering sampling in response to short-term changes (<6 years, or 2 cycles through available panels) in spatial distributions.

Surveys currently don't consider transient environmental factors potentially influencing spatial distributions of murrelet populations (e.g., time of day, tidal stage/flow, etc.). Knowledge of such relationships could allow changes in timing of surveys to more effectively target the desired population or to reduce variability in survey counts. Statistical models of these relationships could increase precision for estimates of population trend, control for variation in environmental conditions, and elucidate resource use. Likewise, refined models of detection probability near the transect center line could also help control for variation related to environmental or survey conditions (see Appendix A).

Ongoing advances in modeling techniques likely will provide increasingly flexible and robust analytic methods for future analyses (see SOP 8). In particular, methods incorporating species identification error, either using estimates derived from field experiments or survey data (Royle and Link 2006, Miller et al. 2011), have potential to reduce bias in population estimates. Simple methods typically used for estimating population trend involve regression analyses applied to individual point estimates of abundance (as in Appendix C). While adequate, these methods may fail to take full advantage of information provided by our models for estimating abundance for each survey year (such as estimates of covariate effects or sampling error). Hierarchical models can naturally combine nested sub-models and estimate trend directly from monitoring data rather than from separate annual abundance estimates (Gelman and Hill 2007, Royle and Dorazio 2008, Cressie et al. 2009). Potential benefits of this approach include avoiding problems arising from doing “statistics on statistics,” controlling for explanatory covariates, selection of an appropriate overall model structure, area-specific estimates of population trend, and increased precision of trend estimates.

7.3 Alternative Design Elements

Protocol development required choice among myriad objectives and sampling designs. Here we present our rationale for excluding some alternatives receiving substantial consideration.

7.3.1 Estimating Abundance of Flying Murrelets

Rapid flight of murrelets grossly violates a critical assumption of distance sampling (Buckland et al. 2001), and including observations of flying birds can create large positive bias in population estimates (van Franeker 1994). However, ignoring these observations excludes the proportion of individuals in flight. Proposed solutions include the ‘vector’ (Spear et al. 1992) and ‘snapshot’ (Tasker et al. 1984) survey methods. The vector method involves estimation of the velocity and direction of flying birds relative to the survey vessel, but drawbacks include requirement of ≥ 1 additional Observer(s), complex and time-consuming estimates (velocity/direction of birds, survey vessel, and wind), and bias/complications arising from bird response to the survey vessel (Hyrenbach 2001, Spear et al. 2004, Borberg et al. 2005). The ‘snapshot’ method entails instantaneous counts of flying birds within a fixed area and is less complex and sensitive to bird response but still requires accurate estimates of large distances and an additional survey Observer (see Appendix A, section A.2.2) and can also have positive bias if counts aren't instantaneous (Gaston et al. 1987).

Both methods are based on strip transect theory, which creates complications because 1) the assumption of complete detection within strips is unlikely to be fully met, especially for small, rapidly flying birds (Barbraud and Thiebot 2009), and 2) integration of population estimates for on-water (using line transect sampling theory) and flying birds (from strip transect sampling theory) is not straightforward (see Appendix A.2.2).

Snapshot methods are further complicated by clumped occurrence typical of seabirds, which leads to zero-inflated data and other forms of overdispersion. Precision of estimates typically is poor, and failure to adequately model overdispersion produces over-estimation of precision (Clarke et al. 2003, Martin 2005, Cama et al. 2011, Zipkin et al. In Press). Furthermore, extant estimators for flying birds would need to be extended for our sampling design as well as to incorporate unidentified flying murrelets, which have been common in prior surveys in Glacier Bay and elsewhere.

We excluded surveying flying murrelets because 1) substantial additional survey effort would be required, 2) extant methods for surveying flying birds would include unknown bias from bird response to the survey vessel, incomplete detection of flying birds, and difficulty of achieving truly instantaneous counts, 3) novel estimators would be required to accommodate our sampling design and methods of allocating unidentified murrelets, 4) estimates likely would be relatively imprecise, and 5) flying murrelets comprise a very small proportion (~2%) of Glacier Bay populations (Kirchhoff and Lindell 2011).

7.3.2 Alternative Sampling Designs

Alleviating imprecision arising from large and somewhat unpredictable within-year variation in encounter rates among transects dominated our selection of a sampling design. Adaptive sampling, which adds local samples when encountering population aggregations, can increase precision in such circumstances, but benefits are sensitive to the magnitude and spatial arrangement of aggregations (Thompson and Seber 1996). We did not favor this approach because its complexity was high, and preliminary analyses suggested aggregations were insufficient to accrue large benefits. Systematic sampling is a simple, spatially-balanced approach to counteracting effects of spatial variation, but lack of appropriate variance estimators for these not fully random designs can substantially diminish efficiency (Thompson et al. 1998, Fewster et al. 2009). Despite promising developments for systematic designs (Fewster 2011), we felt current flux in the field of spatial statistics favored use of more widely-established random designs to maximize alternatives for future analyses. Stratified sampling can also increase precision by grouping similar areas, and we stratified sampling in 2009 pilot surveys based on 1999-2003 spatial distributions of KIMU. However, benefits to precision were small because of disparity between expected and observed distributions (Hoekman et al. 2011a). Because observed annual KIMU aggregations have been somewhat unpredictable and because change in climate or other factors may underpin long-term change in distributions, we opted in 2010 to use a local variance estimator based on post-stratification of encounter rates (see Appendix A, section A.3). This approach avoids pre-defined geographic strata and instead takes advantage of observed spatial variation in data (Hoekman et al. 2011b).

7.3.3 Multi-species Surveys

Marine habitats in GLBA support numerous species of monitoring interest, either because of intrinsic conservation concern or their potential as indicator, flagship, or keystone species. Multi-species surveys present an opportunity to maximize returns from monitoring, and the major prior marine monitoring effort in GLBA (Drew et al. 2008) sought to provide at least population indices for many avian and mammalian species. Our sampling design rested on the twin cornerstones of boat-based, summer surveys focusing on murrelets and sustainable long-term sampling effort (~1/3 that of Drew et al. 2008). We considered complementary monitoring of other marine predators but were unable to identify species that could be adequately monitored without detracting from monitoring murrelets.

Fatal sampling problems (identified from results of Drew et al. 2008 and our unpublished analyses of these data), which make other species inappropriate for inclusion in distance sampling, include low abundance during optimal sampling period for murrelets (e.g., goldeneye [*Bucephala* spp.]), distributions requiring suboptimal allocation of sampling effort for KIMU (e.g., aggregations of diving ducks such as Harlequin ducks [*Histrionicus histrionicus*] in nearshore areas), very high spatial variability in populations (black-legged kittiwakes, mergansers [*Mergus* spp.], scoters [*Melanitta* spp.], sea otters, and harbor seals [*Phoca vitulina*]), rarity of observations (orca [*Orcinus orca*], humpback whale [*Megaptera novaeangliae*]), and

high proportions of flying (black-legged kittiwakes, pigeon guillemot [*Cepphus columba*]) or submerged (harbor porpoise [*Phocoena phocoena*], Steller sea lion [*Eumetopias jubatus*]) individuals.

We felt more appropriate and efficient sampling methods existed for most species considered. Breeding colony surveys (black-legged kittiwakes), haul out counts (harbor seal, Steller sea lion), or aerial line transect surveys (sea otters) were likely to alleviate many above concerns, and adaptive or opportunistic sampling methods may be suitable for rare species (orca, humpback whales, harbor porpoise). Finally, we believed multi-species surveys likely would detract from Observer performance in detecting and identifying murrelets. Given the difficulty and importance of these tasks, we felt maximizing detection and identification of murrelets superseded collection of likely low-quality population indices for multiple species.

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Appendix A: Preliminary Analyses and Analytic Methods

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

A.1 Overview

We sought analytic methods providing estimates of population status and trend with minimal bias and sufficient precision to meet our monitoring objectives in face of sampling challenges, such as incomplete species identification of murrelets, incomplete detection, large spatial and temporal variation in murrelet populations, and convoluted topography of the study area (Hoekman et al. 2011a, b, narrative chapter 2). To gain experience with and test critical assumptions of existing methods, assess novel sampling and analytic methods, and evaluate variation in populations, we collected pilot data, conducted field experiments, and analyzed our pilot data and prior survey data from Glacier Bay (Drew et al. 2008). We present results and recommendations from analyses of our pilot surveys and prior research in section A.2, and in section A.3 we present analytic methods used for population estimates.

A.2 Preliminary Analyses

Conducting pilot surveys allowed us to develop proficiency in survey methods, collect data to inform survey design, and carry out field experiments testing critical assumptions of survey methods. In section A.2.1, we outline results from these data (presented in Hoekman et al. 2011c); we present additional analyses relevant to survey design in A.2.2-A.2.4 and summarize our conclusions and recommendations in A.2.5.

A.2.1 Summary of Hoekman et al. 2011: Line transect sampling for murrelets: Accounting for incomplete detection and identification

During July 2009, we conducted line transect surveys for murrelets in Glacier Bay aboard small boats (≤ 8 m) at speeds of ≤ 10 km/h. Transects were linear, oriented perpendicular to shore, and we stratified sampling effort based on prior densities of KIMU. We also conducted field experiments assessing use of 1 versus 2 survey observers and testing the assumption of complete detection of murrelets near the transect center line. Further, we examined ramifications of incomplete species identification of murrelets and developed analytic methods mitigating negative repercussions (see Hoekman et al. 2011c for further details and citations).

Prior boat-based seabird surveys typically have used either 1 or 2 survey observers, but potential differences in performance were uncertain. We found 2 observers had higher detection probabilities and species identification rates and hence better fulfilled the requirements of line transect methods. A critical assumption of line transect methods is complete detection near the transect center line. We estimated detection probability of 0.94 near the center line and hence employed methods to account for this discrepancy in population estimates.

KIMU and MAMU are morphologically similar and coexist in Glacier Bay, and during pilot surveys we identified <50% of murrelet groups to species. Identification rates have varied widely among prior surveys, and some older studies that did not account for unidentified murrelets were subject to large but variable negative bias in population estimates. We developed analytic methods that account for unidentified murrelet in species-specific population estimates and demonstrated these methods using our pilot data. Our approach assumes the same proportion of each species in the identified and unidentified samples. We feel this approach will be useful in reducing bias and variability in population estimates. We stress that high and accurate species identification rates are essential to reliable estimates. However, we also note that when applying appropriate analytic methods to account for unidentified murrelets, unidentified murrelets likely are much less harmful to estimates than misidentified ones.

Analyses of pilot data also revealed the contribution of short transects to overall variance was disproportionately large and that stratified sampling was only partially effective because the distribution of KIMU deviated from predictions; therefore, we recommended avoiding transects <4 km and use of unequal probability sampling and a spatially-explicit variance estimator to more effectively cope with large annual variation in distributions.

A.2.2 Snapshot Counts of Flying Murrelets

Continuously recording flying murrelets from line transect surveys creates positive bias in population estimates, but excluding these birds creates negative bias (Buckland et al. 2001). We agree with others (van Franeker 1994, Kirchoff 2011) that the 'snapshot' method of counting flying birds can potentially mitigate such bias. Snapshot counts are instantaneous counts of flying birds within a large, fixed area and typically are repeated at short intervals to provide complete, non-overlapping coverage of the transect (Tasker et al. 1984). Relative to 'vector' based methods (Spear et al. 1992), snapshot counts require less difficult field estimates and simpler analytic methods, and they likely are less sensitive to response of birds to the survey vessel. Here we assess potential use of snapshot counts in our sampling design.

The snapshot method assumes complete detection, no bird response to the survey vessel, and accurate distance estimation. Increasing the snapshot area likely reduces potential negative bias from avoidance of the survey vessel, which has been problematic with other seabirds (Borberg et al. 2005). However, increasingly large snapshot areas may decrease accuracy of distance estimation and detection probability, with Barbraud and Thiebot (2009) providing evidence suggesting only ~80% detection for groups of small, rapidly flying seabirds at 200 m.

We posited snapshot counts over a rectangle extending 200 m in front of and perpendicular to the survey vessel. At a survey speed of 10 km/h, snapshots at ~72 s intervals would provide complete, non-overlapping coverage of the transect. Snapshots require observers to 1) locate and track all flying groups prior to the snapshot, 2) disregard groups flushing from the water in the survey area, 3) estimate distance to located flying groups at the instant of the snapshot, 4) count and attempt to identify to species murrelets within the snapshot area, and 5) transmit data to the data recorder. Because concentrations of flying and on water groups often co-occur, we felt the high task load associated with snapshot counts would distract survey observers from on water observations and hence likely would require an additional, dedicated observer.

To estimate total abundance including flying birds, snapshot counts during strip transect surveys typically have been summed with on water counts, assuming complete detection of individuals. However, this method

is inappropriate for line transect surveys because detection probability likely differs between flying and on water groups.

Assuming detection probability for flying groups within the snapshot area is ~ 1 , the Horvitz-Thompson ratio estimator used for line transects sampling (Buckland et al. 2001) could be used to estimate density (individuals/km²) D_f as

$$\widehat{D}_f = \frac{\widehat{E}_f \widehat{S}_f}{2w^2}, \quad \text{A.1}$$

where E_f is groups encountered per snapshot, S_f is the average size of groups, and w is the width (km) of the snapshot area from the center line. Total densities would then be the sum of flying and on water murrelets with additive variances. To posit reasonable values of E_f for our study area, we relied on two prior surveys in Glacier Bay. Drew et al. (2008) conducted strip transect surveys during June 1999-2003 where all flying murrelets were continuously recorded. Average estimated density of all murrelets was $\sim 15/\text{km}^2$, with $\sim 13\%$ in flight. Because some groups will fly through the survey area between snapshots, continuous counts will exceed snapshot counts. We crudely adjusted for this discrepancy by multiplying continuous counts by the ratio of the width of the snapshot area to the travel distance of murrelets moving at 50 km/h over the 72 s snapshot interval, so that predicted mean snapshot count was $15/\text{km}^2 * 0.13 * (400\text{m}/1000\text{m}) \approx 0.8/\text{km}^2$. Kirchoff and Lindell (2011), using the snapshot method, estimated a density of $1.6/\text{km}^2$ for flying murrelets during July 2010 when estimated murrelet densities were $\sim 2x$ higher than 1999-2003. These estimates provided a reasonable range for expected densities of flying murrelets. Because variance in encounter rates has dominated total variance of population estimates from our surveys (Hoekman et al. 2011a, b, c), we assessed utility of snapshot counts by projecting sampling error of estimated densities of flying birds.

For Horvitz-Thompson-like estimators based on the ratio of two means, variance estimates typically asymptotically approach the variance among sampling units. For a random design and in the special case where all sampling units are uniform in size (e.g., the snapshot areas), the variance estimator for encounter rates commonly used for line transect data reduces to the R1 estimator (equation 2) of Fewster et al. (2009), which shows variance in encounter rates is closely approximated by variance in counts among sampling units. Based on the optimistic assumption (but see discussion of overdispersion below) that snapshot counts follow a Poisson distribution, we would expect a variance \approx mean. From the range of expected densities of flying groups, corresponding mean counts per snapshot of 0.06 to 0.13 (expected counts per snapshot = density/area of snapshot) give rise to CVs far greater than one (Figure A.1). This imprecision arises from the large numbers of zero counts, with a few large deviations when counts are ≥ 1 . This simple model illustrates use of the snapshot count as the sampling unit is unattractive for estimation of densities because the rarity of flying birds results in imprecise population estimates.

An alternative approach would be to aggregate snapshot counts over each survey transect. If we assume for simplicity transects with equal length and complete coverage by snapshot counts, density/km² could be estimated as

$$\widehat{D}_f = \frac{\widehat{E}_f \widehat{S}_f}{2wl}, \quad \text{A.2}$$

where E_f is groups encountered per transect, S_f is the average group size, w is the width (km) of the snapshot area, and l is transect length (km). Assuming 5 km transects and the density range above, we could expect $\widehat{E}_f \approx 1.6-3.2$, which would yield far more appealing CVs assuming a Poisson distribution (Figure A.1).

However, estimation of density is further complicated by aggregation typical of seabirds, which for surveys using snapshot or similar methods results in more counts of zero individuals than expected from a Poisson distribution and few counts of large groups (Clarke et al. 2003, Cama et al. 2011). This pattern commonly has resulted in imprecise estimates, and failure to account for overdispersion using appropriate zero-inflated mixture models can produce biased density estimates and underestimates of variance (Martin et al. 2005, Zipkin et al. In Press).

Substantive issues unaddressed by the simple estimator we present above include:

1. Potential for under-estimation of variance if overdispersion is not modeled.
2. The spatially constrained nature of the sample transects.
3. Unequal allocation of sampling intensity.
4. Transects of unequal length.
5. Incomplete identification of murrelets to species and consequent need to allocate unidentified groups to each species.
6. Potential for incomplete detection of flying groups.
7. Difficulty in implementing snapshot counts on zigzag transects.

Our methods (see section A.3) for estimating encounter rate variance for groups on the water could be extended to flying groups. Likewise, Thompson (2012) illustrated how Horvitz-Thompson-like ratio estimators can be extended to include arbitrary sampling inclusion probabilities (e.g., equations 6.9 and 6.10), which likely could also be extended to account for incomplete species identification and unequal transect length.

However, we felt implementing methods for estimation of populations of flying birds was not advised because:

1. Low species identification rates typical for flying birds (Drew et al., unpublished data) would exacerbate estimation problems.
2. Performance of complex, novel estimators required are unknown.
3. An additional survey observer would be necessary to avoid detracting from observations of on-water murrelets.
4. The proportion of flying murrelets in the total population likely is quite low (~2%; Kirchhoff and Lindell 2011)

A.2.3 Probability of Species Identification

High, accurate species identification is critical to avoiding bias and imprecision in population estimates (Hoekman et al. 2011a, c; Hodges and Kirchoff 2012). Low identification rates during pilot surveys were associated with observer inexperience and exacerbated by frequent use of one survey observer (Hoekman et al. 2011c). We hypothesized increased observer experience and use of two observers would increase identification rates and that adverse weather conditions would decrease identification. For 2010 and 2011 survey transects with two observers, we used observations within the right-truncation distance (230 m) defined for detection function analyses to predict probability of species identification using logistic regression, and we selected among alternative models using Akaike's Information Criterion (AIC; Burnham and Anderson 2002). Because we expected identification to strongly decrease with sighting distance, we first selected among three models describing effects of perpendicular distance from the transect center line: 1) intercept only (no effect of distance), 2) linear distance (effect of distance is linear in the logit scale), and 3) quadratic distance (effect of distance is curvilinear in the logit scale). We preferred perpendicular distance from the transect center line rather than initial sighting distance as a predictor because groups closer to the center line often passed near observers as the boat traveled along the transect and hence were more easily identified. After selecting a best model, we then added indicator variables contrasting ideal versus more challenging environmental conditions: Beaufort (Beaufort sea state 0 [calm] versus 1-3 [waves <1 m]) and weather (<50% cloud cover versus >50% cloud cover or mist/rain). Limited samples necessitated pooling more challenging environmental conditions.

A quadratic effect of decreasing identification with increasing perpendicular distance was supported in both years (Table A.1). Evidence for environmental effects was weak, with only a slight increase in identification with <50% cloud cover in 2011 (Figure A.2). Estimated probability of identification in both years approached 95% near the center line but declined sharply at distances >100 m. Relative to 2009 surveys (Hoekman et al. 2011c), more experienced observers in 2010 and 2011 achieved much higher overall identification rates (>75% versus <50%) and exhibited uniformly high identification rates over much larger perpendicular distances. Results from 2009 indicated Beaufort sea state 3 (waves 0.5 -1 m) adversely affects identification. Protocol changes for 2010 and 2011 restricted observations to sea state ≤ 2 (see SOP 1 and protocol narrative), and lack of support for models with Beaufort effects in 2010 and 2011 provided evidence environmental conditions did not negatively affect identification.

A.2.4 Similarity of Detection and Identification between Species

Our methods for allocating unidentified murrelets for species-specific population estimates assumed the same proportion of KIMU versus MAMU groups in the identified and unidentified samples. This assumption was untested but is plausible if detection and identification processes are similar between species. Detection and identification rates during our surveys were inversely proportional with both perpendicular distance from the transect center line (hereafter "center line"; Hoekman et al. 2001c) and the number of groups of each species encountered at a given distance. If detection and identification processes for each species were similar across all distances, then we would expect that the relative frequency of encounters for each species would not vary by distance from the center line. We also hypothesized that any differences in probability of detection or identification would be exacerbated by increasing difficulty in detection and identification associated with increasing distance from the center line.

To assess this hypothesis, we used AIC to select among three logistic regression models expressing alternative effects of perpendicular distance from the center line on the relative frequency of each species encountered during surveys. Regression models included 1) an intercept only model (proportion is unaffected by distance), 2) a model with perpendicular distance from the transect center line as a covariate (proportion is a linear function of distance), and 3) a model with perpendicular distance as a quadratic covariate (proportion is a curvilinear function of distance). Results from both 2010 and 2011 surveys provided strong evidence that relative frequency was independent of distance (Table A.2). Because each additional parameter incurs a “penalty” of ~2 AIC units, AIC differences indicated distance had virtually no explanatory power. These results were consistent with the hypothesis that detection and identification processes were similar between species but could also have occurred if: 1) distance produced opposing effects on probability of detection and identification that counter-balanced each other, or 2) probability of detection and/or identification near the center line differed between species and such differences were consistent across distances. We considered (1) implausible because such counter-balancing would be unlikely and because we expected probability of detection and identification to both decrease with distance. Dismissing (2) is less trivial, but our observations of high detection and identification probabilities near the center line (see sections A.2.1, A.2.3) indicated potential differences were small.

A.2.5 Recommendations from Preliminary Analyses

Our analyses of pilot data and other prior data identified several impediments to effective monitoring, and we recommended adopting several remedies:

Incomplete detection – Murrelets were not always detected, even on the transect center line, resulting in potential negative bias in population estimates using strip or line transect methods. We concluded that line transect surveys, adapted to account for incomplete detection near the transect center line, could avoid such bias and reliably estimate detection probabilities.

Incomplete species identification – KIMU and MAMU could not always be distinguished, and large variation in identification rates and methods of accounting for unidentified murrelets among surveys has resulted in large but variable negative bias in species-specific population estimates. We developed analytic methods accounting for incomplete identification, assuming that probability of detection and identification was similar between species. Available evidence supported this assumption, and we believe this method is likely to minimize bias in population estimates so long as identification rates are moderately high ($\geq 75\%$) and misidentification is infrequent.

2 versus 1 survey observers – Use of 2 survey observers is preferred to 1 on account of higher detection and species identification rates and hence will better meet requirements for reliable estimation of detection probabilities and minimize potential error from incomplete species identification. We advised against surveying flying murrelets because of the need for an additional observer, unresolved statistical difficulties, and the small proportion of flying murrelets in the population.

Annual variation in population hotspots – KIMU occur in dense concentrations that vary in location between surveys. To maximize precision of population estimates, we advocated allocation of sampling effort via unequal sampling probability rather than geographic stratification, application of

a local variance estimator that accounts for spatial variation in data, and avoidance of transects <4 km.

A.3 Methods for Estimation of Density and Abundance

Density and abundance of murrelets will be estimated using line transect methods modified to account for incomplete identification of murrelets to species and incomplete detection near the transect center line. Two software packages will be used to conduct analyses: Program DISTANCE and the R statistical computing environment. Analytic methods in this section are similar to those described by Hoekman et al. (2011c), and we use consistent statistical notation where feasible. Transects from the first stage of our 2-stage sampling procedure were selected using probabilistic methods (see Appendix B, section B.7), and only these are appropriate for analyses of population status. Separate analyses of population trend should use all survey transects.

A.3.1 Detection Probability and Group Size

Program DISTANCE or other software packages may be used to estimate detection probability and group size. Detailed procedures using DISTANCE are presented in SOP 11. Estimation of detection probability across the transect width P_a focuses on estimation of a detection function, which predicts detection probability relative to distance from the transect center line (Buckland et al. 2001). Reliable detection functions should meet the shape criteria of monotonically declining to zero detection probability with increasing distance and having a strong “shoulder” (a region of detection probability ~ 1 extending well away from distance 0). A number of flexible and robust detection functions consist of a key function and possibly an additional series expansion. We consider two key functions, each with two possible series expansions with ≤ 2 expansion terms: half-normal + hermite polynomial or cosine and hazard + simple polynomial or cosine. Exploratory analyses should first set the right-truncation distance w where estimated detection probability declines to ~ 0.15 . Binning of data by distance intervals may help meet shape criteria by alleviating problems associated with animal movement and “heaping” of observations at distances over-utilized by observers. We then use AIC values to select an appropriate detection function structure (key function + series expansion). However, models failing to meet shape criteria may be rejected in favor of more reliable models or may require iterative refinement to exploratory steps described above.

Estimates of detection probability near the transect center line P_c (0.940, SE=0.029, $df=66$) presented by Hoekman et al. (2011c) should be used until these estimates are updated by suitable field experiments.

Because group size has differed among species classes, it should be estimated separately for each. The preferred method is a simple arithmetic average of groups within the right-truncation distance w . However, if smaller groups are less likely to be detected at larger perpendicular distances from the transect center line, then average observed group sizes would under-estimate true group sizes (Buckland et al. 2001). A regression of log (group size) on predicted detection probability may be useful to test if such size-biased detection is occurring. If so, regression-based estimates of group size for detection probability =1 or averages using groups at distances $<w$ may be prescribed.

A.3.2 Encounter Rates

Because of large spatial and temporal variation in distributions of murrelet populations, variance in encounter rates has dominated total variance of abundance estimates for our surveys (Hoekman et al. 2011a, b, c). Our GRTS sampling design and allocation of sampling intensity through unequal probability sampling

should increase precision of estimated encounter rates (see Appendix B, section B.7). However, variance estimators typically used for encounter rates assume a simple random sample and consequently over-estimate variance because they fail to account for spatially-balanced design or similarity of nearby survey transects (Stevens and Olsen 2003, Fewster et al. 2009, Fewster 2011). We utilize a 'local variance' estimator, which uses post-stratification to take advantage of spatial correlation in data (Stevens and Olsen 2003).

Heuristically, variance for each transect is estimated from contrasts with its neighbors, and overall variance is the mean across all transects, weighted to account for unequal sampling probabilities and transect length.

We first estimate the encounter rate E (groups detected/km of transect) for each of three species classes m (i.e., KIMU, MAMU, and unidentified murrelets). For $i = 1$ to k , let t_1, t_2, \dots, t_k be a sample of transects of length l_1, l_2, \dots, l_k selected for sampling with an inclusion probability π_i .

We estimate a weighted mean encounter rate for each species class as

$$\widehat{E}_m = \frac{\sum_{i=1}^k W_i l_i E_{im}}{\sum_{i=1}^k W_i l_i}, \quad \text{A.3}$$

where E_{im} is the encounter rate for t_i and species class m and $W_i = 1/\pi_i$ is the sampling weight for each t_i . To estimate the variance-covariance matrix for these \widehat{E}_m , we create a neighborhood $N(t_i)$ around each t_i typically consisting of the four nearest transects. Using methods of Stevens and Olsen (2003), we defined neighborhoods satisfying $t_j \in N(t_i) \leftrightarrow t_i \in N(t_j)$. Within each neighborhood $N(t_i)$, neighborhood weights w_{ij} are assigned to each transect t_j following the criteria that 1) the w_{ij} should be proportional to W_j and inversely proportional to the distance between t_i and t_j and 2) $\sum_j w_{ij} = \sum_i w_{ij} = 1$.

The variance within each neighborhood provides a variance estimate over a slightly different region. The overall variance estimate is the average of these neighborhood estimates, which are based on contrasts among the neighborhood transects. For estimates of mean encounter rates for each species class, these contrasts are based on the weighted deviations of each transect from the overall mean for that class:

$$r_{im} = W_i l_i (E_{im} - \widehat{E}_m). \quad \text{A.4}$$

If we define the mean of the weighted deviations for a given neighborhood $N(t_i)$ as

$$\bar{r}_{im}[N(t_i)] = \sum_{t_j \in N(t_i)} w_{ij} \cdot r_{jc}, \quad \text{A.5}$$

then the variance of the mean encounter rate for species class m is

$$\widehat{\text{var}}(\widehat{E}_m) = \sum_{t_i} \sum_{t_j \in N(t_i)} w_{ij} (r_{im} - \bar{r}_{jm}[N(t_j)])^2. \quad \text{A.6}$$

The covariance of estimates for any two species classes m_1 and m_2 is

$$\widehat{\text{covar}}(\widehat{E}_{m_1}, \widehat{E}_{m_2}) = \sum_{t_i} \sum_{t_j \in N(t_i)} W_{ij} (\{r_{im_1} - \bar{r}_{jm_1}[N(t_j)]\} \cdot \{r_{im_2} - \bar{r}_{jm_2}[N(t_j)]\}). \quad \text{A.7}$$

We place confidence limits on encounter rates for a specified alpha level α using the critical value for $(1-\alpha)/2$ from a z -distribution so that lower and upper confidence limits are

$$\widehat{E}_{im} - z * \sqrt{\widehat{var}(\widehat{E}_{im})}, \widehat{E}_{im} + z * \sqrt{\widehat{var}(\widehat{E}_{im})}. \quad \text{A.8}$$

A.3.3 Density and Abundance

For a line transect sample, density D typically is estimated as a function of encounter rate E , group size S , strip width w , and detection probability (across the strip width) P_a :

$$\widehat{D} = \frac{\widehat{E}\widehat{S}}{2w\widehat{P}_a}. \quad \text{A.9}$$

To account for incomplete detection on the transect center line and incomplete identification when estimating species-specific densities of murrelets, we estimate adjusted density D' as

$$\widehat{D}'_m = \frac{\widehat{E}'_m\widehat{S}'_m}{2w\widehat{P}_a\widehat{P}_c}, \quad \text{A.10}$$

where P_c is probability of detection near the transect center line and E'_m and S'_m are encounter rates and group sizes adjusted to allocate unidentified murrelets to each species $m = 1$ to 2. Because of similarity in detection processes between species (see section A.2.4), w , P_a , and P_c are jointly estimated for all murrelets. To estimate E'_m and S'_m , we assume the relative encounter rates and group sizes in the identified sample and unidentified sample are the same. We estimate adjusted encounter rates E' for KIMU and MAMU as

$$\widehat{E}'_m = \widehat{E}_m + \left(\frac{\widehat{E}_m}{\widehat{E}_K + \widehat{E}_M} \right) \widehat{E}_U, \quad \text{A.11}$$

where the subscripts K , M , and U denote the KIMU, MAMU, and unidentified species classes. We use the Delta Method (Seber 1982) to estimate the variance of adjusted encounter rates as

$$\widehat{var}(\widehat{E}'_m) = \left(\frac{\partial \widehat{E}'_m}{\partial \widehat{E}_K}, \frac{\partial \widehat{E}'_m}{\partial \widehat{E}_M}, \frac{\partial \widehat{E}'_m}{\partial \widehat{E}_U} \right) \cdot \Sigma \cdot \left(\frac{\partial \widehat{E}'_m}{\partial \widehat{E}_K}, \frac{\partial \widehat{E}'_m}{\partial \widehat{E}_M}, \frac{\partial \widehat{E}'_m}{\partial \widehat{E}_U} \right)^T, \quad \text{A.12}$$

where Σ is the variance-covariance matrix of the estimated encounter rates and T denotes the transpose of the vector of partial derivatives. We calculate confidence limits as in equation A.8.

Group sizes for unidentified murrelets have been larger than for either species. Under the assumption that relative group sizes between species in the identified sample persist in the unidentified sample, average group size for each species in the unidentified sample would differ from that in the identified sample by a constant

$$c = \frac{\widehat{S}_U}{\widehat{S}_I}, \quad \text{A.13}$$

where S_U and S_I denote the unidentified and identified samples.

We estimate S_I as the mean of KIMU and MAMU groups, weighted by their relative frequency as

$$\widehat{S}_I = \widehat{S}_K \left(\frac{\widehat{E}_K}{\widehat{E}_K + \widehat{E}_M} \right) + \widehat{S}_M \left(\frac{\widehat{E}_M}{\widehat{E}_K + \widehat{E}_M} \right), \quad \text{A.14}$$

where K and M denote KIMU and MAMU. We then estimate an adjusted group size for each species $m = 1$ to 2 reflecting the modified group sizes for encounters of unidentified groups:

$$\widehat{S}'_m = \widehat{S}_m \left(\frac{\widehat{E}_m}{\widehat{E}'_m} \right) + c \cdot \widehat{S}_m \left(\frac{\widehat{E}'_m - \widehat{E}_m}{\widehat{E}'_m} \right). \quad \text{A.15}$$

We use the Delta Method to estimate the variance of density estimates as

$$\begin{aligned} \widehat{var}(\widehat{D}'_m) = & \left(\frac{\partial \widehat{D}'_m}{\partial \widehat{E}_K}, \frac{\partial \widehat{D}'_m}{\partial \widehat{E}_M}, \frac{\partial \widehat{D}'_m}{\partial \widehat{E}_U}, \frac{\partial \widehat{D}'_m}{\partial \widehat{S}_K}, \frac{\partial \widehat{D}'_m}{\partial \widehat{S}_M}, \frac{\partial \widehat{D}'_m}{\partial \widehat{S}_U}, \frac{\partial \widehat{D}'_m}{\partial \widehat{P}_a}, \frac{\partial \widehat{D}'_m}{\partial \widehat{P}_c} \right) \\ & \cdot \Sigma \cdot \left(\frac{\partial \widehat{D}'_m}{\partial \widehat{E}_K}, \frac{\partial \widehat{D}'_m}{\partial \widehat{E}_M}, \frac{\partial \widehat{D}'_m}{\partial \widehat{E}_U}, \frac{\partial \widehat{D}'_m}{\partial \widehat{S}_K}, \frac{\partial \widehat{D}'_m}{\partial \widehat{S}_M}, \frac{\partial \widehat{D}'_m}{\partial \widehat{S}_U}, \frac{\partial \widehat{D}'_m}{\partial \widehat{P}_a}, \frac{\partial \widehat{D}'_m}{\partial \widehat{P}_c} \right)^T, \end{aligned} \quad \text{A.16}$$

where Σ is the variance-covariance matrix of the estimated encounter rates, group sizes, and detection probabilities, T denotes the transpose of the vector of partial derivatives, and K , M , and U denote KIMU, MAMU, and unidentified murrelets. Estimated covariances are included only for encounter rate estimates because we could not estimate covariances for other estimates because these have different sampling units or estimators.

We estimate abundance across our study as

$$\widehat{A}_m = \widehat{D}'_m \cdot 1170 \text{ km}^2 \quad \text{A.17}$$

and the variance of these estimates as

$$\widehat{var}(\widehat{A}_m) = \sqrt{\widehat{var}(\widehat{D}'_m) \cdot 1170^2}. \quad \text{A.18}$$

We construct confidence intervals for density and abundance estimates following methods of Buckland et al. (2001) and Fewster (2011). For density, lower and upper confidence limits are $\widehat{D}'_m \cdot L_m$ and \widehat{D}'_m / L_m , where

$$L_m = \exp \left\{ z_\alpha \sqrt{\ln \left[1 + \frac{\widehat{var}(\widehat{D}'_m)}{(\widehat{D}'_m)^2} \right]} \right\} \quad \text{A.19}$$

and z_α is the critical value from a z -distribution for a $(1 - \alpha)/2$ confidence interval. For abundance, we substitute \widehat{A}_m for \widehat{D}'_m . If a lower confidence limit is <0 , then we adjust to one-sided confidence interval by setting the lower limit to 0 and calculating the critical value for the upper limit using $1 - \alpha$. We feel these methods for estimating confidence limits are appropriate because the log-based estimator should provide

good coverage for distributions of \widehat{A}_m and \widehat{D}_m that are expected to be positively-skewed and because approximate degrees of freedom (>30) are sufficient to justify use of the z -distribution.

Because \widehat{E}_m combines three separate estimates of encounter rates (equation A.11), exact degrees of freedom for \widehat{E}_m , and hence \widehat{D}_m and \widehat{A}_m , are unknown. Furthermore, strong covariance in encounter rates among species classes precludes use of standard methods for approximating df , because these methods assume independence among component variables (e.g., Satterthwaite 1946). However, the minimum possible approximate df is the smallest df among the component variables, and we used this minimum as a conservative lower approximate df for \widehat{E}_m . We then apply Satterthwaite's method for \widehat{D}_m and \widehat{A}_m , such that

$$df_{\widehat{D}_m} \approx [\widehat{CV}(\widehat{D}_m)]^4 / \left\{ \sum_{i=1}^m \left[\frac{\widehat{CV}(\widehat{S}_i)^4}{df_{\widehat{S}_i}} \right] + \frac{\widehat{CV}(\widehat{E}_m)^4}{df_{\widehat{E}_m}} + \frac{\widehat{CV}(\widehat{P}_a)^4}{df_{\widehat{P}_a}} + \frac{\widehat{CV}(\widehat{P}_c)^4}{df_{\widehat{P}_c}} \right\}, \quad \text{A.20}$$

where the coefficient of variance CV is the standard error of an estimate divided by the estimate and subscripts on each df denote the degrees of freedom for each estimated parameter. For abundance, we substitute \widehat{A}_m for \widehat{D}_m . These should be interpreted as minimum approximations of df .

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Appendix A Figures and Tables

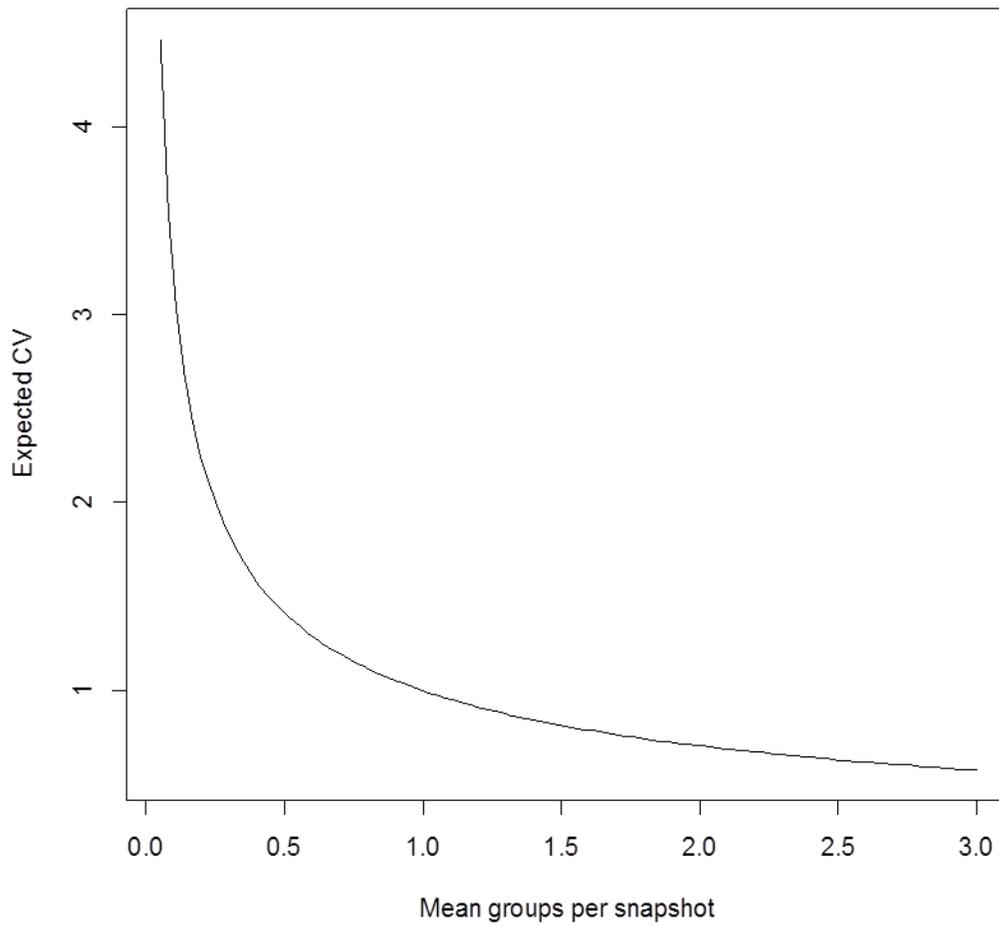


Figure A.1. Expected Coefficient of Variation ($CV=SD/mean$) among snapshot samples relative to expected mean counts of flying groups per snapshot. The relationship assumes counts follow a Poisson distribution.

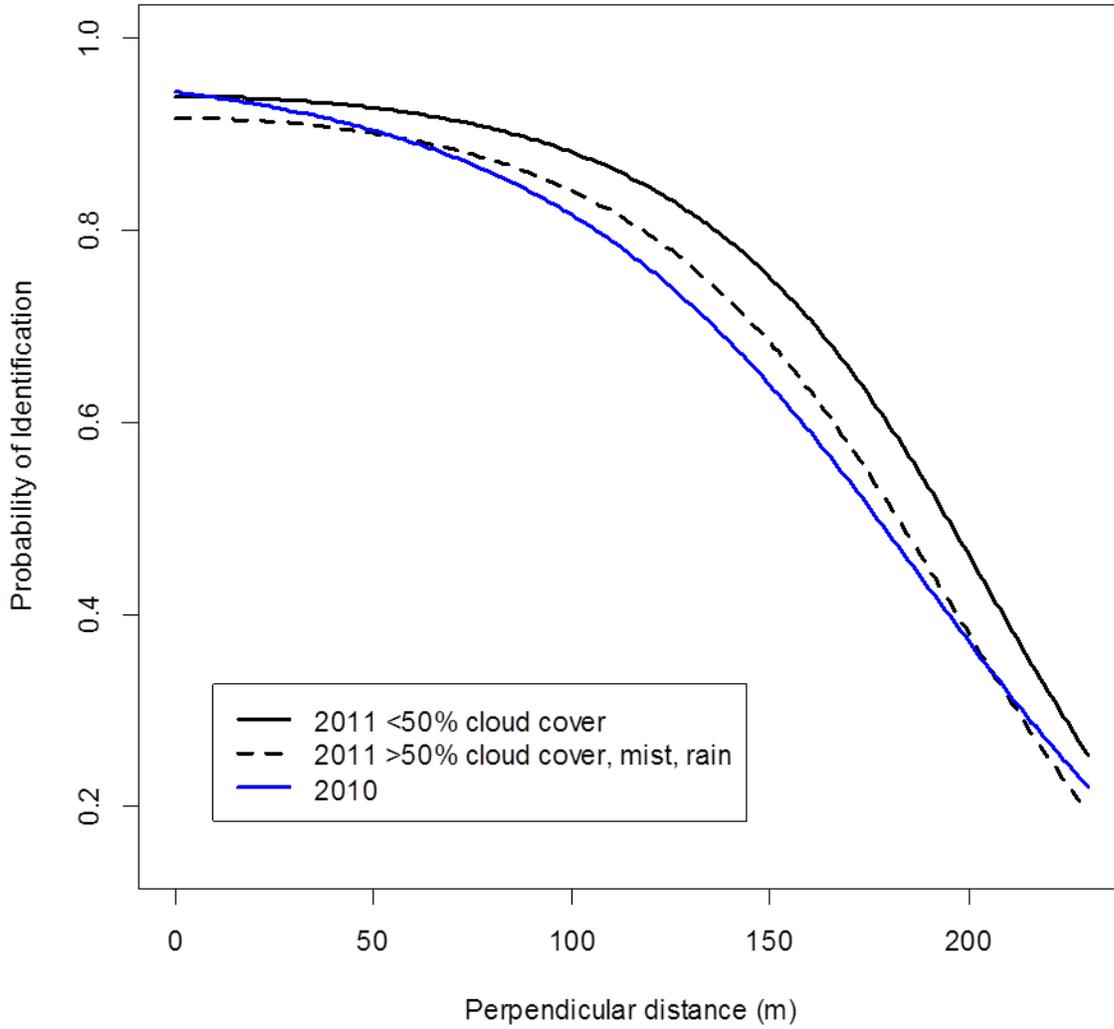


Figure A.2. Estimated probability of identification of murrelet groups to species (Kittlitz's versus marbled) relative to perpendicular distance from the transect center line from line transect surveys in Glacier Bay during July 2010 and 2011.

Table A.1. Model selection results for logistic regression analyses predicting the proportion of murrelet groups identified to species during 2010 and 2011 line transect surveys. All observations (2010, $n = 781$; 2011, $n = 1,490$) taken from transects with two survey observers.

Survey year	Model	Model interpretation	ΔAIC^a	AIC weight ^b	K^c
2010	Quadratic distance ^d	Quadratic (curvilinear) effect of distance	0.0	0.36	3
	Distance ^d	Linear effect of distance	0.1	0.35	2
	Quadratic distance ^d + Beaufort ^f	Quadratic (curvilinear) distance effect, linear Beaufort sea state effect	1.8	0.15	4
	Quadratic distance ^d + weather ^e	Quadratic (curvilinear) distance effect, linear weather effect	1.8	0.14	4
	Intercept only	Identification invariant	168.6	0.00	1
2011	Quadratic distance ^d + weather ^e	Quadratic (curvilinear) distance effect, linear weather effect	0.0	0.69	4
	Quadratic distance ^d + Beaufort ^f	Quadratic (curvilinear) distance effect, linear Beaufort sea state effect	2.8	0.17	4
	Quadratic distance ^d	Quadratic (curvilinear) effect of distance	3.1	0.15	3
	Distance ^d	Linear effect of distance	18.1	0.00	2
	Intercept only	Identification invariant	298.9	0.00	1

^aDifference in Akaike's Information Criterion (AIC) between this model and the best approximating model for each year.

^bWeight of evidence as the best approximating model.

^cNumber of estimated parameters.

^dPerpendicular distance from the transect center line.

^eIndicator variable contrasting <50% cloud cover and >50% cloud cover or precipitation.

^fIndicator variable contrasting Beaufort sea state 0 (calm) and 1-2 (waves <0.5 m).

Table A.2. Model selection results for logistic regression analyses predicting the proportion of groups identified as Kittlitz's murrelets in line transect surveys during 2010 ($n = 781$) and 2011 ($n = 1,490$). All data were taken from transects with two survey observers.

Survey year	Model	Model interpretation	ΔAIC^a	AIC weight ^b	K^c
2010	Intercept only	No effect of distance	0.0	0.63	1
	Distance ^d	Linear effect of distance	1.8	0.26	2
	Quadratic distance ^d	Quadratic (curvilinear) effect of distance	3.6	0.10	3
2011	Intercept only	No effect of distance	0.0	0.61	1
	Distance ^d	Linear effect of distance	1.5	0.28	2
	Quadratic distance ^d	Quadratic (curvilinear) effect of distance	3.5	0.10	3

^aDifference in Akaike's Information Criterion (AIC) between this model and the best approximating model for each year.

^bWeight of evidence as the best approximating model.

^cNumber of estimated parameters.

^dPerpendicular distance from the transect center line.

Appendix B: Characteristics, Placement, and Selection of Survey Transects

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

B.1 Overview

Here we expand on our rationale and methods for selecting survey and alternate transects outlined in sections 2.2-2.4. As described in section 2, traits of our study area and study species imposed numerous technical challenges to our goals of estimating trend (we use trend throughout to refer to change in abundance over time) and status for KIMU and MAMU populations in Glacier Bay, and we developed our sampling design to address these challenges. Our approach was to first create a systematic set of transects meeting our criteria for shape and orientation and also providing reasonable coverage of the survey area. We sought to maximize efficiency in meeting monitoring goals by 1) selecting a random yet spatially-balanced sample using GRTS sampling, 2) allocating sampling intensity proportional to expected population density of KIMU, and 3) implementing an augmented serially alternating panel design with a three year rotation.

B.2 Survey Area and Target Populations

During summer, KIMU are abundant within Glacier Bay proper but sparse elsewhere in GLBA (Romano et al. 2003, Drew et al. 2008). Therefore, our biological population of interest was the population inhabiting Glacier Bay during the breeding season. KIMU cannot always be distinguished from morphologically similar MAMU in the field, and appropriately accounting for unidentified murrelets impelled us to simultaneously estimate population size of MAMU (see Appendix A, section A.3; Hoekman et al. 2011c). For this reason and because of intrinsic conservation interest, populations of MAMU in Glacier Bay during the breeding season were a biological population of secondary interest.

However, numerous geographic and biological factors complicated sampling. Glacier Bay is characterized by complex bathymetry, convoluted topography, strong tidal currents, and numerous boating hazards; we sampled only areas that could be safely traversed at any tidal stage (Figure 2.1). GLBA also designates non-motorized, wilderness, and critical areas to enhance and preserve visitor enjoyment and critical habitat for wildlife of special conservation interest. To maintain integrity of these areas, we sampled only portions of these areas with recent evidence of meaningful KIMU use (Drew et al. 2008). We minimized impact of sampling on wilderness areas by either sampling during dates when wilderness closures were not in effect (Wachusett Inlet, Upper Muir Inlet) or by obtaining NPS access permit (portions of Hugh Miller-Scidmore Complex) specifying minimal time in wilderness areas (see Fig. B.1 for location of place names referenced in this Appendix). We chose not to sample non-motorized waters of the Beardslee Islands because of evidence suggesting low use by KIMU, potential for disturbance of Harbor seals near the Spider Island

Critical Area, and copious navigation hazards. In addition, convoluted topography would require different transect layout than elsewhere in the bay, and limited sight distances imposed by numerous islands likely would challenge assumptions of distance sampling and at bet require independent estimation of detection probability. For sampling the Johns Hopkins critical area, GLBA waived the restriction of maintaining ¼ mile distance to seals hauled out on ice, with the proviso that surveyors monitor seal response to surveys.

Murrelet behavior also limited our ability to sample our biological populations of interest. For murrelet pairs with nests or pre-fledged young, one parent is likely to be at the nest during the day (Day et al. 1999, USFWS 2013). Because accurately sampling inland populations would require separate survey methods (Burger 2001, Cooper et al. 2006), we chose to sample only at-sea murrelets, a subset of the total Glacier Bay population. Small numbers of fledglings also begin arriving on the water during the first half of July (Day et al. 1999), and these are included in our population estimates. On-water breeding season populations of KIMU in GLBA and Icy Bay have been highest in early July, and limited evidence suggests breeding season survey counts have relatively low variation at this time, perhaps because the variable proportion of adults nesting in a given year return to the ocean after nesting (Kissling et al. 2007, Kirchhoff 2011). Higher abundance will also provide larger samples that can increase precision of estimates of detection probability, group size, proportion of each species in the identified sample, etc. Therefore, we followed recommendations for surveys in early July to maximize precision of population estimates (Kissling et al. 2007, Kirchhoff 2011).

Sampling flying murrelets is problematic because their rapid movement creates positive bias in population estimates from line transect sampling (Tasker et al. 1984). We chose not to estimate abundance of flying murrelets because available methods would require an additional survey observer, are still subject to unknown bias, likely would produce imprecise estimates, and would require substantial modification to accommodate our sampling design and murrelets not identified to species (for further discussion, see Appendix A, section A.2.2). Furthermore, murrelets in flight likely only comprise ~2% of the at-sea population in Glacier Bay (Kirchhoff 2008, Kirchhoff and Lindell 2011), and we felt restricting inference to on-water populations was reasonable for our objectives.

The daily timing of surveys also influenced the population we sampled. We restricted sampling to between 08:00-17:00 hours, and our sampling typically has been concentrated between 09:00-15:00 hours (Hoekman et al. 2011a, b). However, large numbers of murrelets, likely mostly MAMU, appear to enter Glacier Bay daily until mid-afternoon and leave the bay after 17:00 (Kirchhoff 2008). Our surveys likely capture most of these daily “commuters.”

In sum, our target populations were a subset of the biological populations of interest defined by timing, location, and behavior. Our target populations were on-water KIMU and MAMU during diurnal sampling hours from early to mid-July. Target populations were a surrogate to our biological populations of interest. Our survey area was defined by the area of Glacier Bay from which we drew samples (Figure 2.1).

B.3 Transect Characteristics: Overview

Precision of estimates of population status is strongly inversely proportional to power to detect trend in status over time (Gibbs et al. 1998). As is typical of surveys using distance sampling methods, total sampling variance of our population estimates has been dominated by imprecision arising from variation in encounter rates (observed groups/km) among transects (Buckland et al. 2001, Fewster et al. 2009, Hoekman et al.

2011a, b, c). Therefore, we prioritized minimizing this variance component by favoring transects that were precisely repeatable, ~4-8 km in length, and oriented perpendicular to population density isolines while providing reasonably uniform coverage across the study area. Systematically placed linear and zigzag transects fulfilled these criteria.

B.4 Transect Characteristics: Length

For a given level of survey effort, a trade-off exists between average length and number of transects. Shorter length increases transect number, with benefits of increased sample size and hence precision for estimation of encounter rates, better spatial coverage of the study area, and reduced crew fatigue associated with surveying for long transects. However, longer transects can minimize variability in encounter rates among transects (and hence precision of estimates) and time in transit between transects relative to time surveying. Variance of population estimates for murrelets in Glacier Bay has been dominated by variance in estimates of encounter rates (Hoekman et al. 2011a, b, c); hence, maximizing their precision is paramount. Murrelet populations in Glacier Bay are highly variable in space and time, and most line transect estimators are highly sensitive to variability in encounter rates among transects (Fewster et al. 2009; Appendix A, section A.3.2), implying benefits from longer transects that average out local variability. However, optimal balance between transect length and number depends on the magnitude and spatial scale of variability in encounters. Prior research in Glacier Bay suggested decreasing variability in encounter rates with increasing transect length became much less pronounced for lengths ≥ 4 km (Drew et al. 2008). Similarly, a short transect (~2.5 km) substantially decreased precision of estimated encounter rates and abundance during pilot surveys (Hoekman et al. 2011a). Therefore, we preferred transects of 4-8 km in length to minimize variability in encounter rates among transects while maximizing sample size of transects and spatial coverage of the study area.

B.5 Transect Characteristics: Shape and Orientation

Alaskan fjords and archipelagos present substantial challenges to sampling and navigation, and murrelet surveys in Alaska have employed linear, zigzag, and non-linear transects (Raphael et al. 2007, Kirchhoff 2011, Madison et al. 2011, Piatt et al. 2011). Non-linear transects have paralleled convoluted coastlines and are difficult to replicate because of required judgment of distances, changes in topography with tidal stage, and numerous nearshore navigation hazards. We favored linear and zigzag transects, because precise replication made possible by GPS navigation equipment decreases spatial variation in survey counts and ensures safe navigation routes.

Distributions of murrelets appear to be highly responsive to water depth and/or distance from shoreline, especially showing sharp density gradients in nearshore areas (Rachowicz et al. 2006, Kissling et al. 2007, Kirchhoff 2011, Piatt et al. 2011). In Glacier Bay, the highest concentrations of murrelets have been focused in a relatively narrow band in areas of intermediate water depth (50-150 m) and at ~200-600 m from shore (Drew et al. 2008, Kirchhoff 2011, Drew et al. 2013). Geographic pre-stratification of sampling can help mitigate decreased precision of population estimates caused by spatial variation (Rachowicz et al. 2006, Drew et al. 2008, Morrison et al. 2008) by segregating relatively high density nearshore versus offshore areas. Where convoluted coastlines predominate, stratified sampling of nearshore areas have utilized non-linear transects paralleling shorelines at fixed (Kissling et al. 2007, Drew et al. 2008) or ad hoc (Van Pelt and Piatt 2003) distances. We felt this approach was suboptimal for Glacier Bay, because small deviations in paths of non-linear transects could lead to unequal sampling intensity across steep density gradients and hence increased variability or bias in encounter rates. Furthermore, stratification of near and offshore areas

coupled with narrow, complex waterways would complicate representatively sampling all habitat types. Geographic pre-stratification is most useful for large scale, predictable gradients (Thomas et al. 2007), but nearshore gradients and other aggregations of murrelets in Glacier Bay (e.g., Drew et al. 2008, Figure 8; Kirchhoff et al. 2010, Figure 7; Kirchhoff 2011, Figure 2) have been relatively fine-scaled. Finally, line transect sampling assumes objects are distributed randomly with respect to transects (Buckland et al. 2001), which may be untrue for transects oriented parallel to density isolines.

If density gradients are short relative to transect lengths and geographic stratification cannot effectively be implemented, orienting transects perpendicular to density isolines (i.e., perpendicular to shoreline) will reduce variability among transects and increase precision of population estimates (Buckland et al. 2001, Fewster and Buckland 2004). This approach also naturally facilitates representative sampling across the density gradient and all habitat types. Hence, we preferred transects oriented perpendicular to shoreline.

B.6 Transect Characteristics: Placement

Based on above considerations, we favored linear transects between 4-8 km in length oriented perpendicular to shorelines. In relatively linear fjords covering most of the survey area (82%), linear transects running shore-to-shore perpendicular to the local prevailing shoreline met these criteria; we employed zigzag transects to ensure similar characteristics in narrow and convoluted areas (18%). Our sampling frame consisted of systematic placed transects; systematic placement facilitated control of transect characteristics and also avoided problems associated with intersecting transects and potential for disturbance between transects (Buckland et al. 2001). GRTS sampling selection from the sampling frame (see section B.7.3) assured randomization of our survey transects.

B.6.1 Linear Transects

For the purpose of placing linear transects, we defined three transect areas with a similar prevailing shoreline (Table B.1, Figure B.2), and the overall axis of each transect area defined the perpendicular orientation of transects within each area. We systematically generated transects by selecting a random starting point along the main axis and then placing parallel transects at distance interval $y_l = \frac{2}{3}$ km. Where the width of the main bay exceeded 10 km, we split transects into two along an axis extending north from Strawberry Island, through Boulder Island, and north to the headland separating the east and west arms of Glacier Bay. In addition to maintaining desired transect lengths, this split followed a strong gradient in observed densities of KIMU and facilitated allocation of sampling effort relative to density (section B.7.1). Transects were also split where obstructed by non-navigable barriers > 0.5 km in width. Transects were not split when encountering small and could be easily circumnavigated obstacles; surveys simply were paused and then resumed after clearing the obstruction (see SOP 1).

B.6.2 Zigzag Transects

In areas such as narrow fjords or channels between islands and the mainland, linear transects perpendicular to shore would not reach desired lengths. For areas with average width <2.5 km, we defined 19 zigzag transect areas (Table B.1, Figure B.2). As for linear transect areas, we defined a main axis for each zigzag transect area perpendicular to the prevailing shoreline. We defined separate transect areas where a large change (>15°) in the prevailing shoreline occurred. Zigzag transects in each area traversed from shore-to-shore at angles <90°. To achieve adequate coverage of narrow, irregular areas, transects were defined by waypoints along the shorelines of each sampling area that were evenly spaced with respect to distance along

its main axis (Buckland et al. 2001). Although not perpendicular to density isolines, each zigzag segment traversed the entire population density and water depth gradients and hence provided reasonably representative coverage. The linear segments also satisfied our requirement of repeatable safe navigation.

Using Rendu Inlet as an example (Figure B.3), transect waypoints occurred on each shore at each distance interval y_z along the main axis, and the zigzag trajectory can follow alternating waypoints along either side of the inlet. The angle θ defines the deviation of the transect path from the main axis and hence the typical angle of approach to the shore (the actual angle of approach depends on local topography). The turn in the transect path at each shore creates an area of overlap where animal groups can be observed from two different transect segments, and observers must take care to properly record observations (see SOP 1). Because overlap increases with increasing θ , we preferred $\theta < 60^\circ$ to minimize difficulties for observers. Small values of θ can also create problems with excessive transect length and failure to traverse from shoreline-to-shoreline within the length of the transect area, so we also avoided $\theta < 30^\circ$.

B.6.3 Coverage Probability

Mixing linear and zigzag transects in the same survey area required careful assessment of coverage probability (i.e., the average probability of a location being covered by a survey). Most sampling designs rely on the assumption that all locations are equally likely to receive coverage from a sampling unit. If we assume an idealized rectangular area of length Y and width X and also that a survey covers an area of width w along a transect (Figure B.4A), then coverage probability for a linear transect area is

$$\frac{w}{y_l} \tag{B.1}$$

The constant value of y_l ensures relatively uniform coverage probability throughout the linear transect areas. For zigzag transect areas, however, coverage probability for a given y_z varies with X as

$$\frac{ws}{y_z X}, \tag{B.2}$$

where $s = \sqrt{X^2 + y_z^2}$ is the length of each zigzag line segment (Figure B.4B).

In order to properly allocate sampling intensity (see section B.7), it was useful to achieve equivalent coverage probability across areas, or at least to know the relative coverage probabilities. To achieve desired sampling coverage in linear versus zigzag areas, we altered y_z relative to the width of each zigzag transect area. If we define c as the proportional sampling coverage of linear relative to zigzag transect areas for any given X , y_l , and y_z , then we can set equations B.1 and B.2 as equivalent so that

$$\frac{w}{y_l} = \frac{wsc}{y_z X}. \tag{B.3}$$

Substituting for s gives

$$\frac{1}{y_z^2} = \left(\frac{1}{c^2}\right)\left(\frac{1}{y_l^2}\right) - \frac{1}{X^2}. \tag{B.4}$$

Thus, for any area of width X , we can adjust y_z for zigzag transects to produce a specified proportional coverage relative to linear transects with interval y_l . When equal coverage is desired (i.e., $c=1$), the first term in parentheses on the right side of the equation vanishes. As an example, Figure B.4A shows transect coverage of a rectangular area with the distance interval $y_z=0.67$, and Figure B.4B and C show identical coverage probability for zigzag transects in areas with different widths. Adjustments in y_z result in corresponding changes to θ and s .

To systematically place transects within each zigzag transect area, we first approximated X for each area as the mean length of a large number of lines extending perpendicular from the main axis to each shore. For areas with $0.75 < X < 1.35$ km, we used a value of $c=1$ in equation B.4 to calculate y_z producing equivalent coverage probability with linear transect areas that also satisfied our requirement of $30^\circ < \theta < 60^\circ$. In each area, a random number r in the interval $(0, y_z)$ provided the starting point along the main axis, with subsequent intervals every y_z (Figure B.3). Waypoints were placed at the intersection of a perpendicular line extending from the distance interval on the main axis with the shoreline. Starting from a randomly selected side, the transect trajectory followed waypoints along alternate shores. At the first and last waypoints along each main axis, transects continued on the side of the main axis opposite the previous segment at angle θ until intersecting shore. We combined adjacent zigzag segments until transects fell within the preferred range of 4-8 km.

For areas with widths between 2.5 and 1.35 km, y_z needed to solve equation B.4 with $c=1$ resulted in $\theta > 60^\circ$. To obtain θ within the preferred range, we proceeded using $c=2$, resulting in acceptable values of θ , but sampling coverage in these zigzag transect areas was half that of linear areas. Transects were constructed as described above. To ensure these areas were sampled at desired sampling intensities, we adjusted the inclusion probability of transects in these areas by 200% when drawing our GRTS sample (see section B.7.3).

One zigzag transect area was so narrow ($X=0.58$) that sampling coverage was greater than for linear transect area even when y_z approached infinity. For this area, we used $c=2/3$, meaning coverage was 150% of that in linear transect areas. We achieved equivalent sampling coverage with linear transect areas by randomly removing $1/3$ of the segments for this area.

B.7 Selection of Transects for Sampling

The systematically placed transects defined above defined the sampling frame (Fig B.2) from which we selected survey transects and alternate transects, which replaced survey transects that were unsuitable for sampling. To minimize deleterious effects of large spatial and temporal variation in murrelet populations on our goals of monitoring trend and status, we preferred to implement a spatially-balanced sampling design that also accommodated unequal allocation of sampling intensity and that would fit within a panel design. GRTS sampling is a novel sampling method that provides a spatially-balanced yet random sample (Stevens and Olsen 2004). The random design also allowed us to take advantage of a novel local variance estimator based on geographic post-stratification (Stevens and Olsen 2003) that offers increased efficiency and flexibility in mitigating effects of spatial variation relative geographically pre-stratified designs.

B.7.1 Allocation of Sampling Effort

GRTS sampling allows unequal inclusion probabilities for each sampling unit, meaning that a unique sampling intensity could be assigned to each transect. Optimal sample allocation strategies have not been

explored for the local variance estimator that we employed (Stevens and Olsen 2003). For simple random and other sampling designs, typical optimal sampling strategies for maximizing precision suggest allocation of sampling effort proportional to the within-stratum standard deviation (SD) among sampling units (e.g., Cochran 1977, Thompson 2002). A similar strategy of allocating effort proportional to the SD in the local neighborhood around each sampling unit (*sensu* Stevens and Olsen 2003) can reasonably be expected to be similarly beneficial using the local variance estimator (D. L. Stevens, personal communication).

Implementing a strategy of allocating sampling intensity relative to variation among sampling units depends on effective prediction of future variation. During our pilot surveys, total variance in estimates of population status for murrelets was dominated by spatial variation in encounter rates among transects (Hoekman et al. 2011a, b, c).

We hypothesized that the SD in encounter rate among transects would be directly proportional to mean encounter rates, based on the observations that encounter rates (integer counts of groups of murrelets encountered per linear km of transect) arise from a Poisson-like process (discrete values over continuous space) and that the variance of the Poisson distribution equals the mean (Hilborn and Mangel 1997). To explore this hypothesis, we used our 2009 pilot survey data (Hoekman et al. 2011a) to estimate mean encounter rates and the SD among transects within two strata and for KIMU, MAMU, and unidentified murrelets. Results were consistent with a 1:1 relationship between these parameters (Figure B.5), and we concluded that expected density would be a suitable proxy to variation in encounter rates for allocation of sampling intensity.

Because our primary objective was monitoring trend and status of KIMU, we allocated sampling effort based on expected population densities of this species. We relied on two prior population surveys for murrelets to describe spatial and temporal variation in densities within Glacier Bay: strip transect surveys conducted by the U.S. Geological Survey (USGS) during June 1999-2003 (Drew et al. 2008) and line transect surveys from our pilot field season during July 2009 (Hoekman et al. 2011a). Differences in methods, most notably in handling of incomplete detection and incomplete identification, precluded direct comparisons of densities between surveys (Hoekman et al. 2011b). However, indices to density would be sufficient to guide allocation of sampling intensity, given the 1:1 correspondence between the variance and mean of density estimates. We preferred the USGS surveys as our primary source, because these provided superior inter-annual replication and spatial coverage (4x sampling effort of 2009 surveys).

We derived expected densities of KIMU from spatially explicit estimates of population density pooled across 1999-2003 (see Drew et al. 2008, Figure 12e). KIMU in Glacier Bay have shown highly aggregated distributions, with more than an order of magnitude difference in mean density over several hundred meters commonly observed. To maximize benefits, we were compelled to match this fine-grain spatial variation when estimating mean densities. Starting with the linear and zigzag transect areas (Table B.1, Figure B.2), we divided these areas into 33 sub-regions containing relatively homogenous densities and habitat types (Table B.2, Figure B.6). Based on mean densities within each sub-region, we created five groupings of sub-regions with similar densities so that densities roughly doubled between each density group (Table B.2). Densities for Johns Hopkins Inlet were unknown, and we placed this area in the intermediate density group.

We also defined a group of special concern areas, which totaled five transects in areas characterized by either unusually high murrelet densities (Reid Inlet, central portions of Hugh-Miller Scidmore Complex), cultural

or recreational value (Hugh-Miller Scidmore non-motorized waters), or importance to other species of management concern (Johns Hopkins Critical Seal Habitat). We selected for inclusion only the northernmost transect in Johns Hopkins Inlet because surveys had the lowest probability of being impeded by dense ice.

We did not feel confident that the 1999-2003 surveys adequately captured the full range of variation in distributions, as areas with large aggregations in some years were virtually unoccupied in others (Drew et al. 2008, Figure 8). Furthermore, correspondence of estimated distributions from 2009 with the 1999-2003 results was moderate. In particular, an unusually large aggregation in the Beardslee Channel suggested other future aggregations in unexpected locations. Additionally, impetus for change in distributions are not well-understood (Robards et al. 2003, Kissling et al. 2007), and close association with glacially-influenced habitats (Kuletz et al. 2003) in concert with potential glacial recession (Arendt et al. 2002, IPCC 2007) may presage directed change in distributions over longer time scales. Therefore, we were concerned that aggressively allocating sampling intensity based these prior surveys would be suboptimal if future distributions deviated from those observed in prior surveys. Negative consequences of improperly allocating sampling effort include decreased precision of population estimates as well as decreased capacity to track distribution changes. Therefore, we preferred a conservative approach of allocating sampling effort more uniformly than the potentially optimal strategy presented above. We calculated inclusion probabilities for density groups so that a doubling of mean density for each group resulted in a 50% increase in selection as a survey or alternate transect (Table B.2). For additional details on inclusion probabilities and transect selection, see section B.7.3 below.

B.7.2 Panel and Revisit Design

Optimal revisit designs (how sample units are visited over time) for monitoring vary relative to monitoring objectives and variability in monitored populations (Urquhart and Kincaid 1999, McDonald 2003b). We sought a revisit design that would balance our objectives of monitoring trend and (primarily) status for KIMU and (secondarily) MAMU in the face of substantial spatial and temporal variation in populations. As discussed in section 2.3, the only effective remedy for negative effects of high coherent annual variation on trend detection over time is accruing a longer time series (Urquhart et al. 1998, Larsen et al. 2001). Based on large variation among annual populations estimates for Glacier Bay (e.g., Hoekman et al. 2011b), we viewed annual sampling as necessary. Murrelets in Glacier Bay have also exhibited high ephemeral annual variation (Drew et al. 2008; Kirchhoff et al. 2010; Hoekman et al. 2011a, b; Kirchhoff 2011) and possibly also substantial within sampling period variation (Romano et al. 2007, Kirchhoff 2008); we mitigated effects these variance components on estimation of trend and status by maximizing sites visited each sampling period (Larsen et al. 2001).

Large spatial variation observed for murrelet populations in Glacier Bay (Drew et al. 2008; Kirchhoff et al. 2010; Hoekman et al. 2011a, b; Kirchhoff 2011) has large implications for between sampling period revisit design. High spatial variation renders designs based on randomly revisiting units much less effective in estimating trend than designs based on planned revisits (Urquhart and Kincaid 1999). Panel designs (where a panel refers to a group of sample units always visited at the same time) are planned revisit designs specifying how panels are revisited between sampling periods, and alternative panel design strategies provide specific advantages and drawbacks relative to monitoring.

Designs specifying revisiting all sampling units each sampling period have been advocated for monitoring trend because detrimental effects of spatial variation among units are negated (Skalski 1990). Simulation studies (Urquhart et al. 1998, Urquhart and Kincaid 1999) have supported the “always revisit” approach as superior for estimation of temporal trend but as poor for assessing status. Assessment of status benefits from maximizing total sites visited, but “never revisit” designs (new sample units each sampling period) are superior for assessing status but poor for trend.

Split panel designs offer intermediates between these extremes (McDonald 2003b). For example, serially alternating designs specify visiting panels at regular intervals, increasing total units (and hence precision of status estimates) while retaining benefits of revisiting units periodically. In practice, split panel designs often can provide reasonable status estimates with very little loss in precision of trend estimates relative to the “always revisit” design (Urquhart et al. 1998, Breidt and Fuller 1999), and thus satisfied our objective of balancing monitoring of trend and status. The value of longer revisit intervals increases with times series length (Urquhart et al. 1998). We favored a relatively short 3-year serial panel to conform with monitoring objectives and an assumed 10-15 year window for providing policy-relevant monitoring information.

Augmented designs also include a panel that is visited each sampling period. We preferred this approach because our augmented, serially alternating panel design was “connected” in the statistical sense, meaning that trend analyses could be conducted using standard linear models (Urquhart and Kincaid 1999). We modified the standard augmented design to improve spatial coverage of the sampling area. Our methods of allocating sampling intensity relative to expected densities of KIMU resulted in uneven sampling of the survey area. High density areas (density groups 4-6 in Table B.2) comprised $\sim 1/4$ of the survey area, but $> 1/2$ of sampling effort was expected to fall in these areas. Such sparse coverage of low density areas (density groups 1-3 in Table B.2) was problematic, because it would provide inadequate information about current distributions of populations and future changes relative to changing climate and habitat.

Therefore, we maximized coverage of low density areas by assigning transects from the high density groups to the augmented panel and assigning transects from the low density groups to the 3 serially alternating panels (using methods described below). This approach allowed us to maximize capacity to estimate trend if high density areas continued to receive highest use, but also allowed us increase spatial coverage in low density areas to capture current and future population distributions.

B.7.3 GRTS Selection

We drew a GRTS sample from our sampling frame using Program S-Draw version 1.0 (T. L. McDonald, available from <http://www.west-inc.com>). We treated transects as discrete sampling units, with the mid-point between the transect endpoints describing the spatial arrangement of transects in 2-dimensions. For a brief description of S-Draw functions and options, see McDonald (2003a) included with the S-Draw software package download. We selected the following options: 2-dimensional structure, unequal probability sample, a pixel size of 1 m, random seed set by computer clock, randomization of the hierarchical structure (recommended by Stevens and Olsen 2004), and sorting by reverse hierarchical order (recommended by Stevens and Olsen 2004). Program inputs were x - and y -coordinates for transects and a weight specifying the relative inclusion probability for each transect.

Weights in S-Draw are scaled to have a value of one for the sampling unit with the lowest inclusion probability. For our density groups $i = 1$ to 6 (Table B.2), we calculated the weight w_i for transects in each group based on the expected density for each group d_i relative to that in the first group d_1 , so that

$$w_i = 1 + 0.5 \left(\frac{d_i - d_1}{d_1} \right). \quad \text{B.5}$$

The 0.5 term is a slope parameter specifying that a doubling of expected density results in a 50% increase in inclusion probability. These w_i expressed the relative probability that a transect in a given density area would be included in our survey sample in a given year. We made two adjustments to calculated w_i when drawing our survey sample. First, because sampling coverage of systematic transects in some zigzag transect areas was half that in most other areas (see section B.6.3), we doubled the calculated w_i for transects in these areas to achieve desired sampling intensity. Second, our panel specified that we select a single augmented panel for high density areas (density groups 4-6) but that we select three alternating panels to be sampled on a three-year rotation. Therefore, we divided w_i by three for high density areas (density groups 4-6) so that the 3x increase in relative inclusion probability for low density areas would appropriately populate the alternating panels.

Our annual sampling target was ~250 km of transects. We specified S-Draw output 100 transects in an ordered list, which has the property that any set of contiguous elements within the list constitutes a random, spatially-balanced sample (Stevens and Olsen 2004). We created three sets of transects by advancing down the list until reaching the transect that gave a cumulative distance of transects closest to 250 km and then starting the next set from the third transect after the endpoint. All transects from the higher density areas were assigned membership in the augmented panel. Transects from lower density areas in each of the three sets were assigned membership in the respective three alternating panels. The two transects after each set were alternate transects to be used in place of any transects in the respective set that were permanently unsuitable for sampling. Because of strong interest in monitoring areas of special concern (density group six; Table B.2, Figure B.6), we used a 2-stage selection process to insure their selection. After generating the ordered list as described above, any transects in density group six not selected in the augmented panel were then inserted in a random position in one of the three sets of transects, displacing subsequent transects to a lower position in the ordered list. Transects were then reassigned panel membership based on the new order. Because transects added in the second step were not selected using probabilistic methods, these added transects were useful for monitoring trend but tended to over-represent areas of high density and hence should not be used to assess population status.

This procedure resulted in an augmented serially alternating panel design (Figure B.7) that was random, spatially-balanced, had an average total transect length of 252 km annually, and that appropriately weighted sampling intensity according to inclusion probabilities in Table B.2. Among transects in density group six, all were selected during probabilistic sampling with the exception of one transect in Scidmore Bay. This transect (016 in Figure B.7) was added to the probabilistic sample and hence is appropriate for inclusion in analyses of trend but not status; it had an inclusion probability = 1. In total, 88 transects (467 km) were selected: 25 permanent transects (144 km) in the augmented panel, 15 transects (83 km) in the year 1 panel, 21 transects each in the year 2 (126 km) and 3 (144 km) panels, and 6 alternate transects (27 km).

Analyses of unequal probability samples (see Appendix A, section A.3) require calculation of inclusion probabilities, which are the probability of a sampling unit being included in the sample. For transects in each density group, we calculated probability of inclusion p_i in the sampled panel as:

$$p_i = p_1 w'_i, \quad \text{B.6}$$

where w'_i is the w_i calculated in equation B.5 adjusted by dividing by three for high density groups to account for the three alternating panels. The total number of sampled transects in the survey panels n_s defines the inclusion probabilities so that

$$\sum_{i=1}^k p_i n_i = n_s, \quad \text{B.7}$$

where n_s was the 81 transects in our panel selected using probabilistic methods and n_i was the number of transects in each density area. For transect areas with sampling coverage $\frac{1}{2}$ that in most other areas, we counted each transect as two when calculating n_i . By substituting for p_i from equation B.6, we obtained

$$\sum_{i=1}^k p_1 w_i n_i = n_s. \quad \text{B.8}$$

Solving for p_1 yields

$$p_1 = \frac{n_s}{\sum_{i=1}^k w_i n_i}, \quad \text{B.9}$$

and p_i for each density group can then be calculated using equation B.7. To express these p_i as probability of inclusion of transects in the survey sample in a given year, we divided p_i in low density groups by 3 (Table B.2), and these adjusted values constituted the inclusion probabilities π_i in Appendix A, section A.3.2.

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Appendix B Figures and Tables

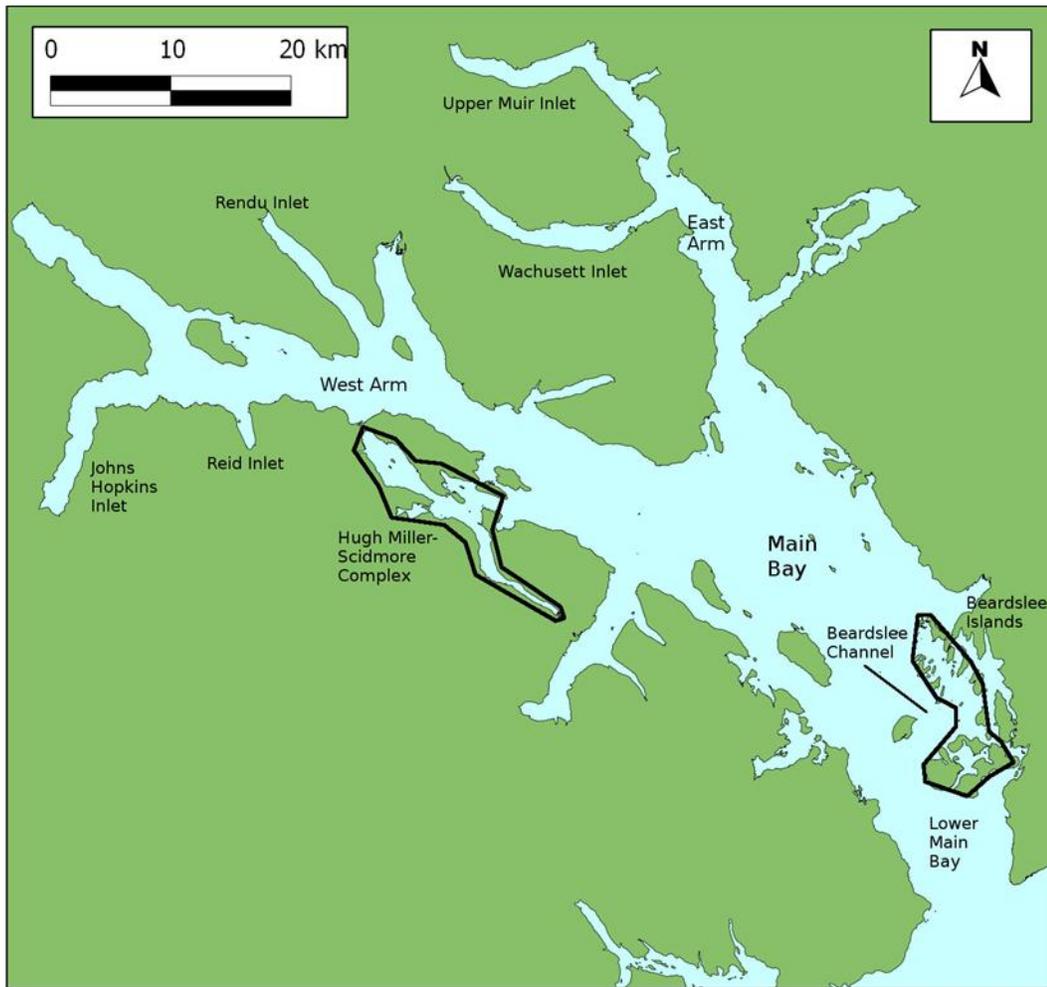


Figure B.1. Place names within Glacier Bay referenced in text.

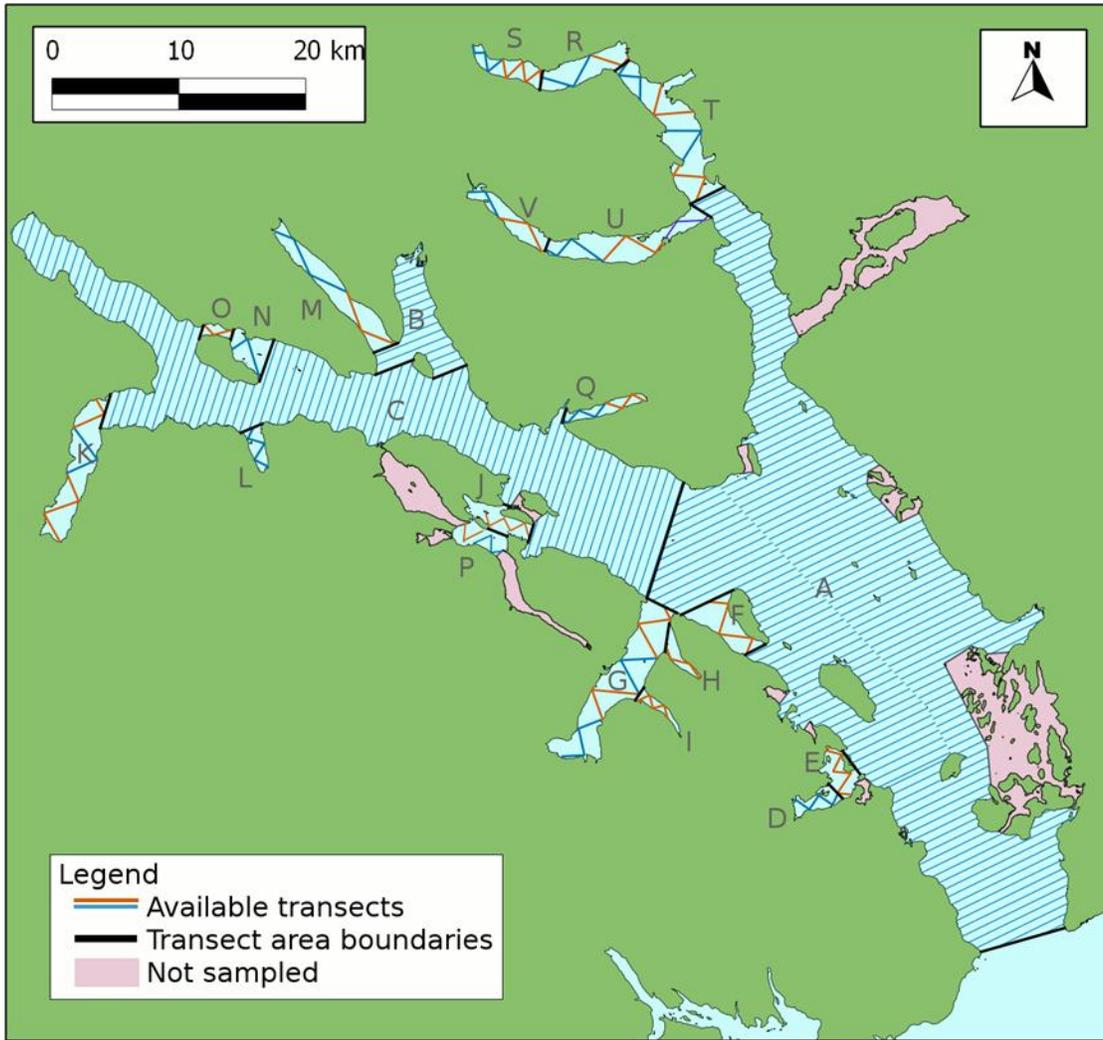


Figure B.2. Our sampling frame consisted of systematically placed transects within survey area. Black lines separate linear or zigzag transect areas; letters correspond to sampling area labels in Table B.1. Blue and red lines show transects.

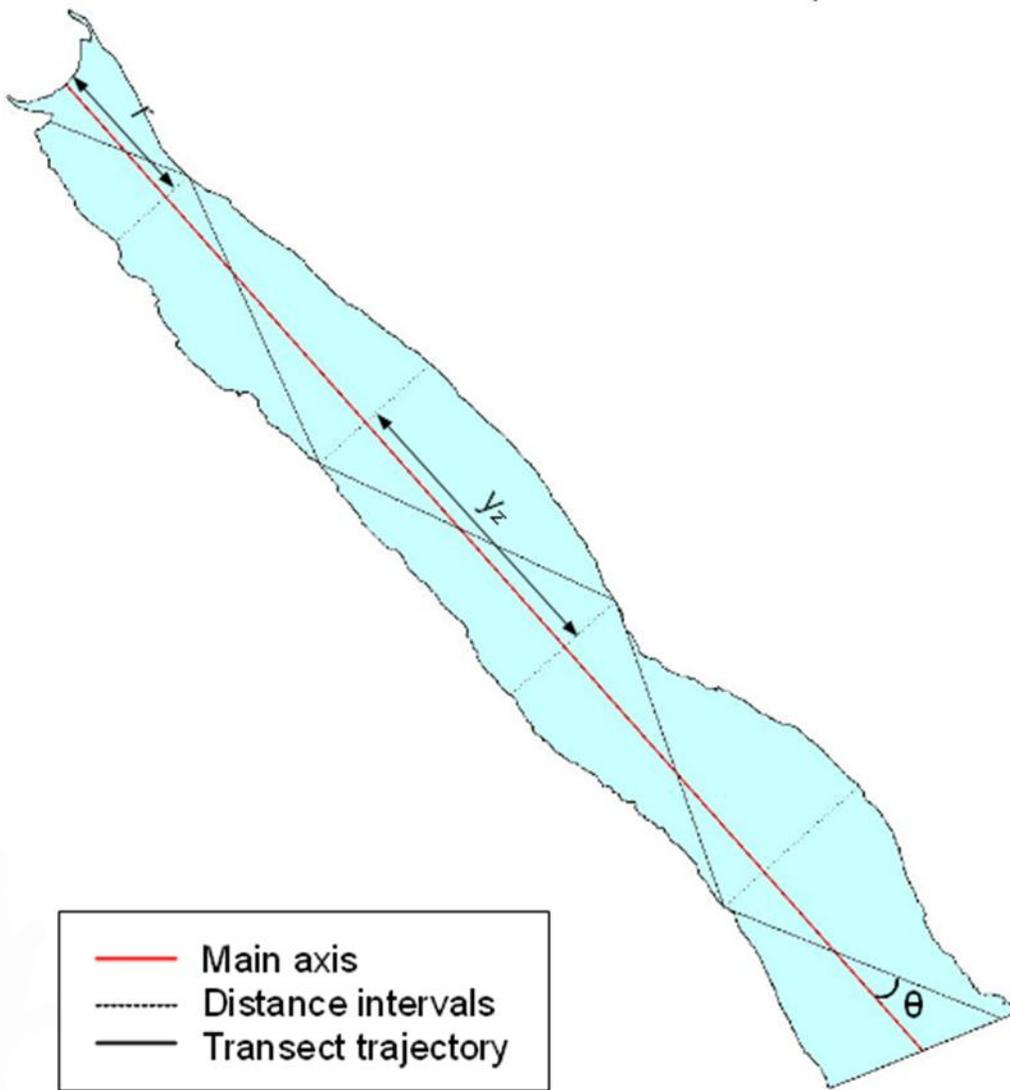


Figure B.3. Zigzag transect sampling applied to Rendu Inlet. The main axis defines the orientation of the transect area. Transect waypoints occur on each shoreline at distance interval y_z along the main axis. The transect trajectory follows sequential waypoints on alternating shores, with the starting side and initial distance interval r randomly determined. The first and last transect segments extend to the boundary of the sampling area at angle θ relative to the main axis.

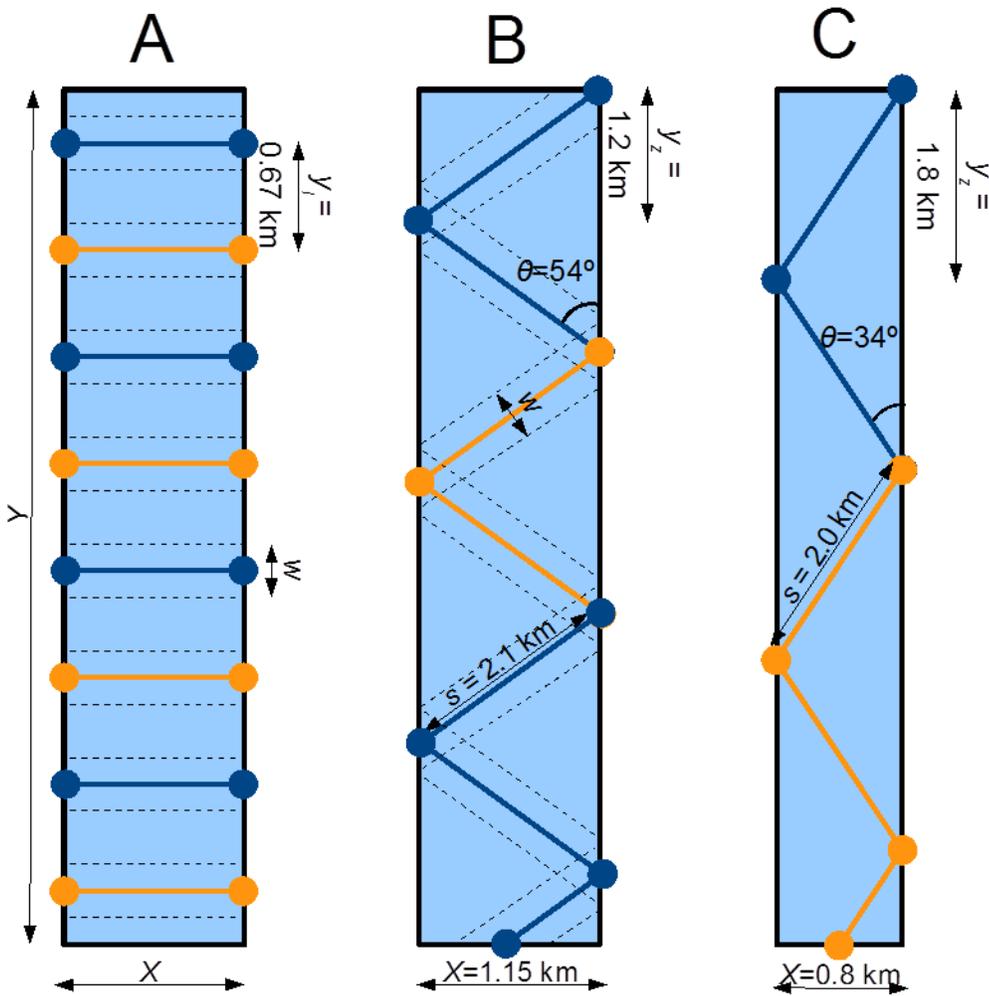


Figure B.4. Examples of equal sampling coverage for a rectangular region of arbitrary width X and height Y with linear, parallel transects (A) and for areas of differing width X with zigzag transects (B, C). For A, sampling coverage is determined by the interval between transects y_1 and width of transect coverage w . For B and C, sampling coverage is determined by the interval between waypoints y_z , X , and w . For a given X , altering y_z changes the angle of approach to shoreline θ , length of each transect segment s , and hence sampling coverage.

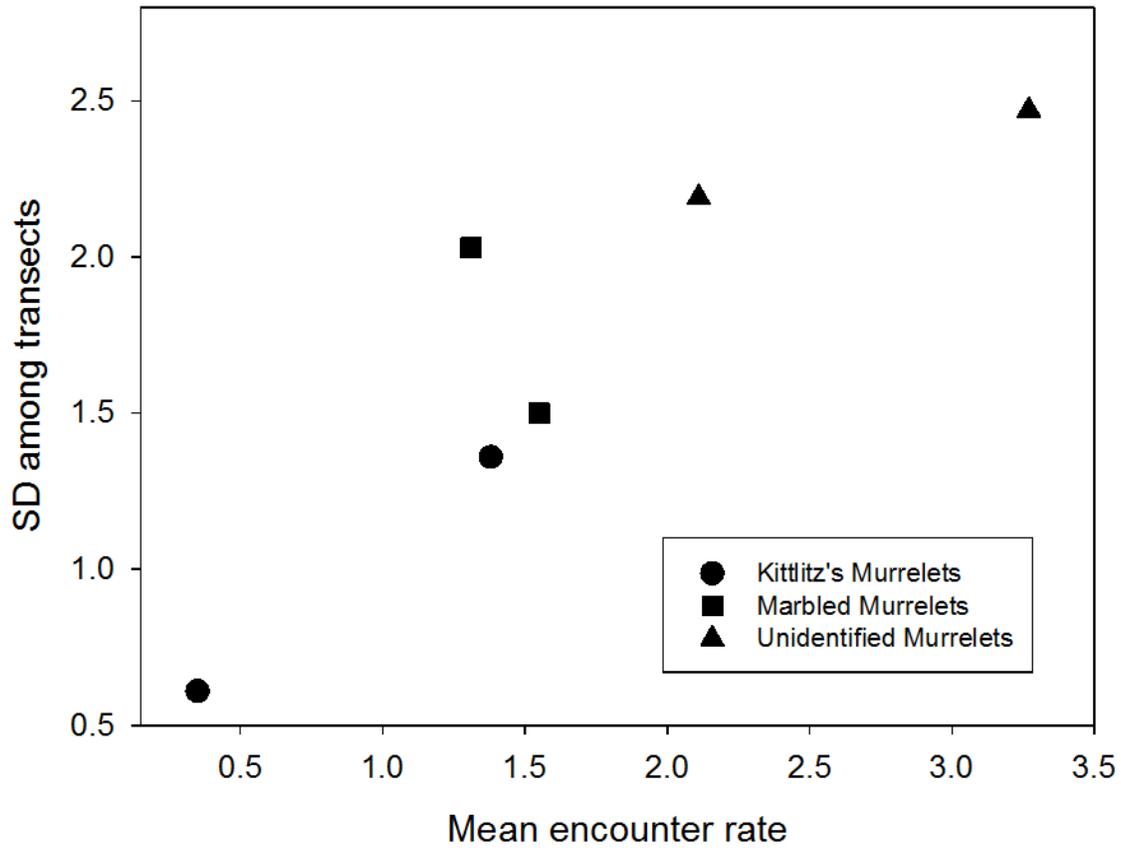


Figure B.5. Estimated standard deviation SD in encounter rates (groups/km) among transects relative to estimated mean encounter rates. Estimates are presented separately for Kittlitz's, marbled, and unidentified murrelets for two geographic strata.

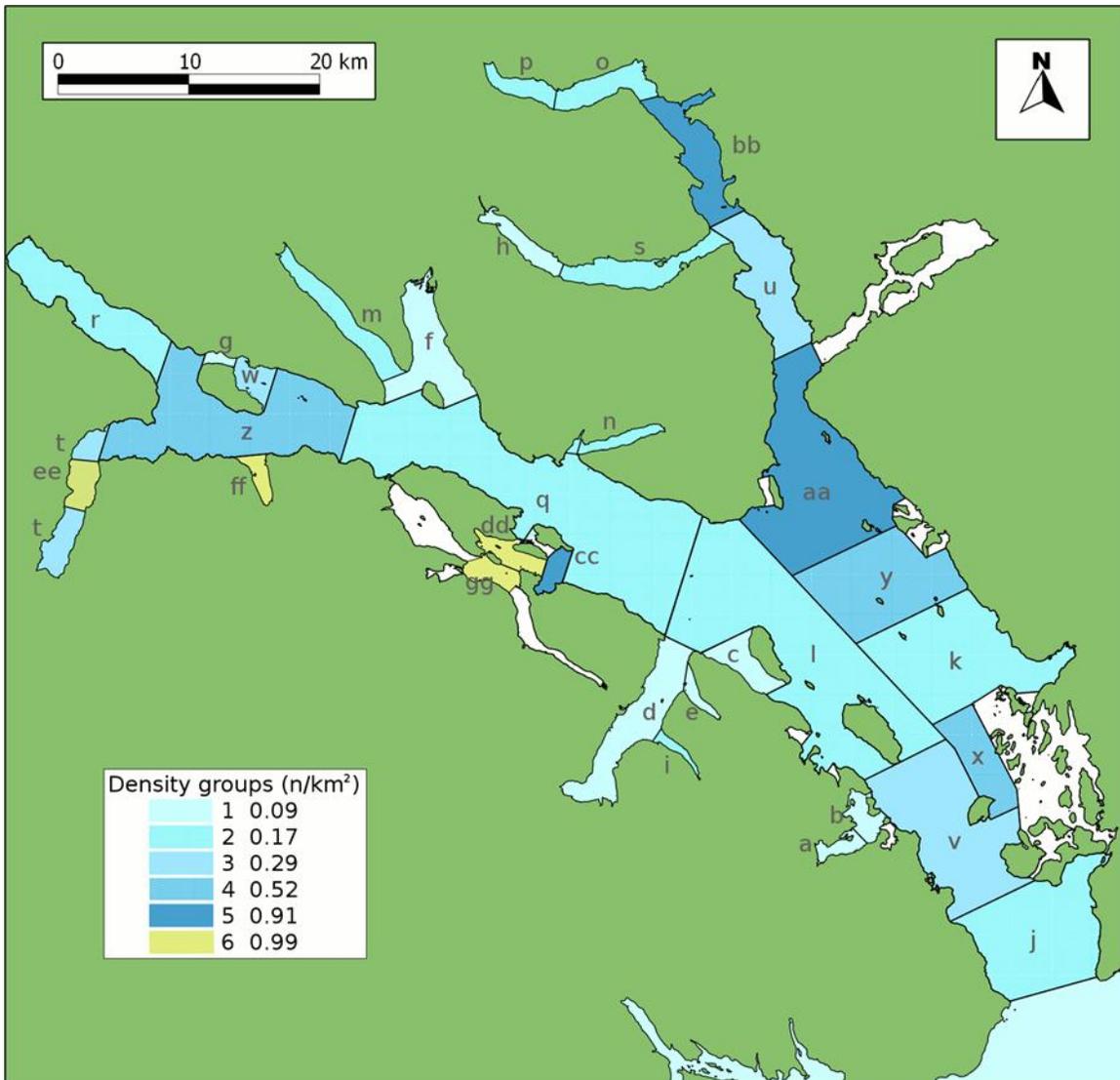


Figure B.6. Density groups used to allocate sampling intensity. Expected densities of Kittlitz's murrelets (birds/km²) for survey sub-areas (labeled with lowercase letters as specified in Table B.2) were calculated using strip transect survey data of Drew et al. (2008). Density groups 1-5 created by pooling sub-areas with similar expected densities nearly doubled expected density between successive groups. Density group 6 was comprised of smaller areas of special concern (high Kittlitz's murrelet density or other management interest).

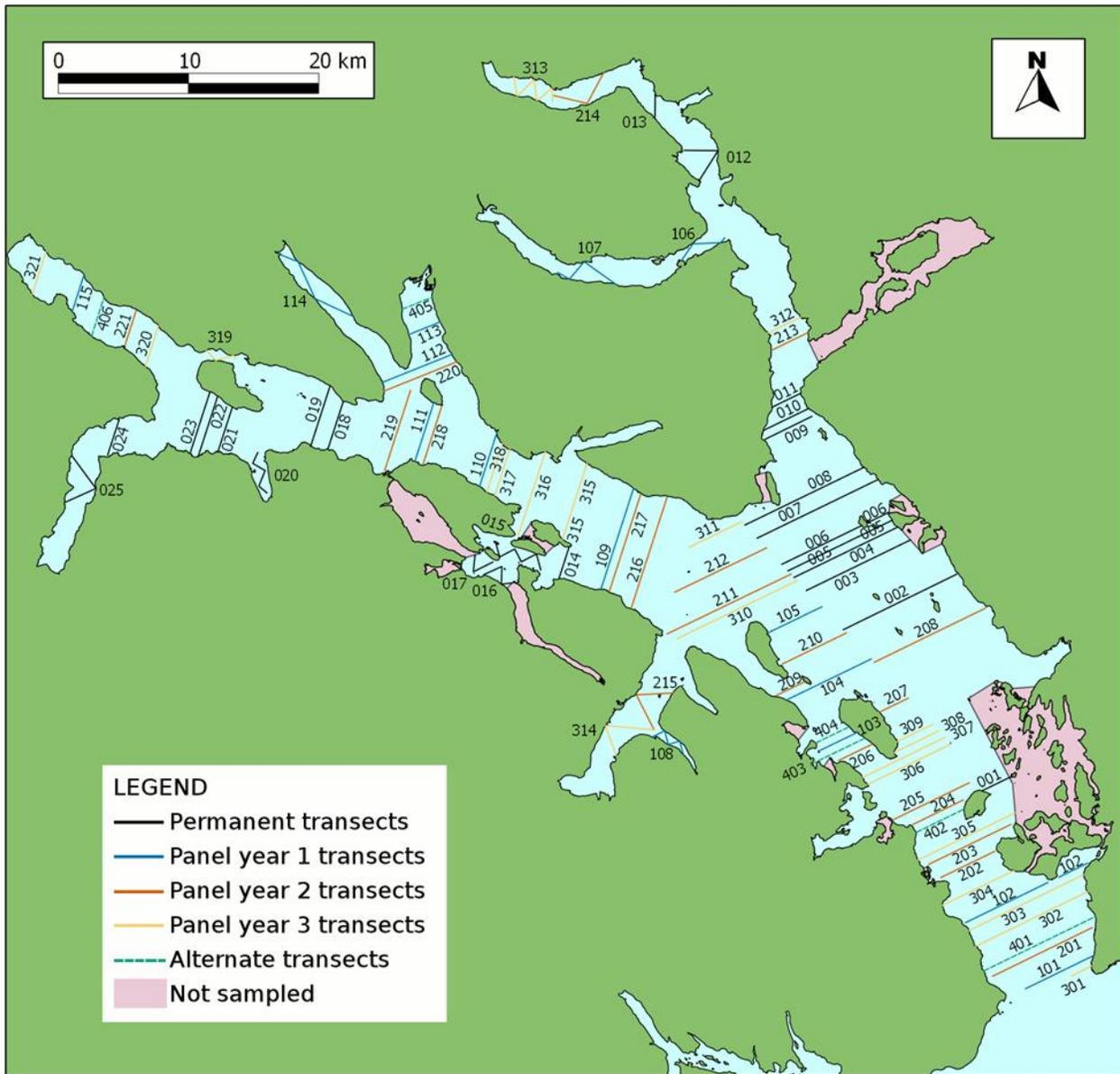


Figure B.7. Transects selected for line transect surveys for murrelets in Glacier Bay and assignment of transects within an augmented serially alternating panel design. Transects in the permanent panel are sampled annually, while transects in the alternating panels are sampled on a three year rotation. Alternate transects are used if the panel transects are unsuitable for surveys.

Table B.1. Properties of linear and zigzag transect areas defined within Glacier Bay survey area. Axis orientation and width (zigzag areas only) were used to determine parameters y_1 (linear transects only), y_2 (zigzag only), and θ (zigzag only) used to systematically place transects. See text for additional details.

Transect type	Transect area	Map ID ^a	Axis orientation ^b	Width ^c (X)	Distance interval ^d (y_1 or y_2)	Angle off axis ^e (θ)	Relative sampling coverage ^f
Linear	Main bay	A	351	-	0.67	-	1.0
	Queen Inlet	B	355	-	0.67	-	1.0
	West arm	C	304	-	0.67	-	1.0
Zigzag	Berg Bay E	D	166	1.14	0.82	54	1.0
	Berg Bay W	E	95	0.96	0.93	46	1.0
	Drake Island	F	165	2.23	1.66	53	0.5
	Geikie Inlet	G	47	2.44	1.59	57	0.5
	Shag Cove	H	148	0.77	1.36	29	1.0
	Tyndall Cove	I	131	0.58	0.69	40	1.0
	Hugh Miller Inlet	J	129	1.09	0.84	52	1.0
	Johns Hopkins Inlet	K	35	1.99	1.80	48	0.5
	Reid Inlet	L	174	1.03	0.84	50	1.0
	Rendu Inlet	M	155	1.49	2.97	27	0.5
	Russell Island E	N	123	2.11	1.72	51	0.5
	Russell Island W	O	122	0.79	1.24	33	1.0
	Scidmore Bay	P	143	1.35	0.77	60	1.0
	Tidal Inlet	Q	91	0.84	1.11	37	1.0
	Muir Inlet NE	R	87	1.72	2.11	39	0.5
Muir Inlet NW	S	128	1.34	0.77	60	1.0	
Muir Inlet	T	162	2.42	1.60	57	0.5	
Wachusett Inlet E	U	96	1.71	2.12	39	0.5	
Wachusett Inlet W	V	143	1.71	2.12	39	0.5	

^aCode used to identify transect areas in Figure B.2.

^bBearing (degrees) of axis, parallel to prevailing shoreline.

^cAverage width (km) of area perpendicular to axis.

^dDistance (km) between parallel linear transects (y_1) or between waypoints on the main axis (y_2).

^eDeviation (degrees) of the of zigzag transect segments from the main axis.

^fRelative probability that a location within a sub-area would be covered by a survey, scaled to one for typical sampling coverage.

Table B.2. Average estimated densities (birds/km²) of Kittlitz's murrelets for individual and grouped sub-areas. Density groups 1-5 combined sub-areas with similar density estimates so that average density roughly doubled for each successive group. Group 6 combined areas of special interest; see text for additional details. Average group density and relative sampling coverage were used to define sampling inclusion probabilities for systematically placed transects in each sub-area. Inclusion probabilities are used for sample selection and data analyses for unequal probability sampling. (Continued)

Group	Sub-area	Map ID ^a	Estimated density 1999-2003 ^b (n/km ²)	Average group density ^c	Percent of survey area	Sampling weight (w _i)	Inclusion probability ^d
1	Berg Bay E	a	0.08	0.09	9	1.0	0.06
	Berg Bay W	b	0.08				
	Drake Island	c	0.08				
	Geikie Inlet	d	0.09				
	Shag Cove	e	0.08				
	Queen Inlet	f	0.08				
	Russell Island W	g	0.12				
	Wachusett Inlet W	h	0.08				
2	Tyndall Cove	i	0.23	0.17	51	1.4	0.08
	Main Bay S	j	0.19				
	Lower Main Bay E	k	0.20				
	Main Bay W	l	0.15				
	Rendu Inlet	m	0.21				
	Tidal Inlet	n	0.17				
	Muir Inlet NE	o	0.19				
	Muir Inlet NW	p	0.19				
	West Arm E	q	0.16				
	Tarr Inlet	r	0.20				
Wachusett Inlet E	s	0.17					
3	Johns Hopkins Inlet ^e	t	-	0.29	12	2.0	0.12
	Muir Inlet S	u	0.32				
	Sitakaday Narrows	v	0.26				
	Russell Island E	w	0.41				

Table B.2. (continued) Average estimated densities (birds/km²) of Kittlitz's murrelets for individual and grouped sub-areas. Density groups 1-5 combined sub-areas with similar density estimates so that average density roughly doubled for each successive group. Group 6 combined areas of special interest; see text for additional details. Average group density and relative sampling coverage were used to define sampling inclusion probabilities for systematically placed transects in each sub-area. Inclusion probabilities are used for sample selection and data analyses for unequal probability sampling.

Group	Sub-area	Map ID ^a	Estimated density 1999-2003 ^b (n/km ²)	Average group density ^c	Percent of survey area	Sampling weight (w)	Inclusion probability ^d
4	Beardslee Entrance ^f	x	0.32	0.52	15	3.3	0.19
	Middle Main Bay E	y	0.51				
	West Arm W	z	0.58				
5	Upper Main Bay E	aa	0.97	0.91	12	5.4	0.31
	Muir Inlet	bb	0.72				
	Hugh Miller entrance	cc	0.76				
	Hugh Miller Inlet	dd	1.47				
6	Johns Hopkins Inlet ^e	ee	-	0.99	2	5.8	0.34
	Reid Inlet	ff	1.50				
	Scidmore Bay	gg	0.66				

^aCode used to identify sub-areas in Figure B.6.

^bFrom Drew et al. (2008).

^cThe average density estimate for each density group.

^dProbability of a transect within each density group being selected for sampling in a given year.

^ePlaced in intermediate density group because prior densities were unknown, excepting one transect placed in density group 6 on account of high use by breeding harbor seals.

^fPromoted from group 3 to 4 because of very high densities in this sub-area recorded during 2009 surveys (Hoekman et al. 2011a).

Appendix C: Detecting Population Change

Version 1.0

Revision History Log:

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

C.1 Overview

Our primary objective was to achieve at least 80% power (the probability of rejecting a null hypothesis of no decline when it is false) to detect a 33% decline in KIMU over a 15 year period, with a secondary objective of similar power for MAMU. When information about variability in population estimates exist, power analyses can be useful in designing and evaluating population surveys (Taylor and Gerrodette 1993, Steidl et al. 1997). Prior surveys in Glacier Bay provide substantial information about murrelet populations in our survey area. However, utility of prior information for conducting power analyses for our survey design were limited by: differences in methods among surveys that complicated integration of information, complexity of our survey methods, and uncertainty about key descriptors of population variability. Because returns from complex and time-consuming power analyses were likely to be limited, we opted to conduct relatively simple power analyses focusing on assessing capacity of our design to meet objectives and quantifying effects of key uncertainties.

C.2 Existing Information

A key input for power analyses is expected variation of estimates around a population trend (Hatch 2003). However, numerous prior population surveys for murrelets in Glacier Bay (Kendall and Agler 1998, Lindell 2005, Romano et al. 2007, Drew et al. 2008, Kirchhoff 2008, Kirchhoff et al. 2010) differed in survey areas, timing of surveys, allocation of sampling intensity, and methods of accounting for flying birds, unidentified birds, and detection probability. These differences introduced variable levels of bias in population estimates and complicate comparisons among most surveys and reliable estimation of variability in population estimates (Hoekman et al. 2011a, b; Kirchhoff 2011). Population estimates of Drew et al. (2008) were the longest continuous data stream (1999-2003) and used consistent methods. Hence, these data likely provided the best information on among-year variability in population estimates. Drew et al. (2008) concluded that power to detect declines in murrelet populations approached our stated objectives, but they assumed a level of annual sampling effort (~1100 km of transects) far greater than for this protocol (~250 km). While useful in characterizing variability in murrelet populations and amount of strip transect sampling needed to monitor populations, their results were of limited utility to planning our design because of substantial differences in survey and analytic methods. Therefore, we opted to assess power for our survey design.

C.3 Power Analyses

C.3.1 Objectives

Our objectives for power analyses were to assess whether our sampling design was likely to meet to meet our objectives for detecting population declines and to quantify uncertainty in population variability and its implications for monitoring. Variability in population estimates combines two components (Link and Nichols 1994): true variation in the population over time (hereafter “process variation”) and variation due to sampling error (hereafter “sampling variation”). We estimated process variance in populations of murrelets in Glacier Bay from results of Drew et al. (2008) using methods described below (section C.3.2). Sampling variation is a function of statistical methods used, variability in the data, and sample size. For many surveys involving count data, projection of sampling variation has relatively straightforward closed form solutions. However, our population estimates synthesized results of several component estimators (see Appendix A, section A.3). Simulation methods would be required to project sampling variation for some of these estimators on account of their complexity. In particular, variation in encounter rates likely will dominate the sampling variance of future populations estimates (See Appendix A, section A.3.2), but simulating performance of the local variance estimator will require reliable knowledge of the magnitude and spatial distribution of variation in populations. Large uncertainty in the magnitude of variation in populations (see below) coupled with unpredictable changes in distributions suggested large investment in simulation of power for alternative sampling designs would yield little reliable information. Therefore, we opted for a simple approach of assessing capacity of our sampling design to meet monitoring objectives and on how uncertainty in population variability affected conclusions.

C.3.2 Methods

We estimated process variation in murrelet populations in Glacier Bay using estimates from strip transects conducted during June 1999-2003 reported in Drew et al. (2008), as these represented the only extended data stream using consistent methods. These surveys did not account for detection probability or unidentified murrelets. Therefore, estimates provided a negatively biased index to population size, and annual variation in estimates also reflected variation in detection probability and identification. Assuming a ~1:1 relationship between the estimates and population size, we felt these data could provide a reasonable estimate of process variation in populations.

Using estimates of annual abundance and average sampling variance from the two strata model presented in Appendix 5 of Drew et al. (2008), we estimated process variance and associated confidence intervals using modifications of methods in Burnham et al. (1987). If A_i represents abundance of a population that is sampled over a series of years $i=1$ to n , then the total variance in estimates of the population will be

$$var(\hat{A}_i) = \sigma^2 + var(\hat{A}_i|A_i), \quad C.1$$

where σ^2 is the process variance (true variation in the population) and $var(\hat{A}_i|A_i)$ is the conditional sampling variance of \hat{A}_i . Assuming sampling variances are constant among A_i , the process variance can be estimated using the sample standard deviation of the estimates as

$$\sigma^2 = \frac{1}{n-1} \sum_{i=1}^n (\hat{A}_i - \hat{A})^2 - \widehat{var}(\hat{A}_i|A_i). \quad C.2$$

We assumed this simplification, because only the average sampling variance across years was reported in Drew et al. (2008).

We estimated a 90% confidence interval for our estimates of σ^2 using a χ^2 distribution. For the desired α level of 0.10, we estimated the lower confidence limit by iteratively solving for $\hat{\sigma}_L^2$

$$\frac{1}{n-1} \sum_{i=1}^n \left(\frac{1}{\hat{\sigma}_L^2 + \widehat{var}(\hat{A}_i|A_i)} \right) (\hat{A}_i - \hat{A}) = \frac{\chi_{n-1, \alpha/2}^2}{n-1}, \quad \text{C.3}$$

where $\chi_{n-1, \alpha/2}^2$ is the critical value from the χ^2 distribution. The upper confidence limit by solving for $\hat{\sigma}_U^2$

$$\frac{1}{n-1} \sum_{i=1}^n \left(\frac{1}{\hat{\sigma}_U^2 + \widehat{var}(\hat{A}_i|A_i)} \right) (\hat{A}_i - \hat{A}) = \frac{\chi_{n-1, 1-\alpha/2}^2}{n-1}. \quad \text{C.4}$$

However, for both species, the lower confidence limit was ≤ 0 . Therefore, we set $\hat{\sigma}_L^2 = 0$ and created a one-sided confidence interval by solving equation C.4 using α in place of $\alpha/2$.

We used the average sampling variance of abundance estimates for each species from 2010-2012 surveys as an estimate of sampling variances for our study design (Hoekman et al. 2013). Because of large differences in abundance estimates between studies, we expressed variation as coefficients of variation (CV) to facilitate comparison. We projected the CV of total annual variability in estimates of population abundance over time from the sum of the estimated process (from Drew et al. 2008) and sampling variance (from Hoekman et al. 2013):

$$CV(\hat{A}_i) = \sqrt{\left(\frac{\hat{\sigma}}{\hat{A}_i} \right)^2 + \left(\frac{\widehat{var}(\hat{A}|A)}{\hat{A}} \right)^2}. \quad \text{C.5}$$

We assessed power to detect population declines in each species for two scenarios: a population declining 33% over 15 years (2.6% annually) and a population declining 50% over 10 years (6.7% annually). For the first, we also estimated power using estimates of total variation in annual estimates using the upper and lower 90% confidence limits for estimates of process variance in equation C.5.

We calculated power to detect decline using methods described by Gerrodette (1987) and Program TRENDS version 3.0 (available at <http://swfsc.noaa.gov/default.aspx>). For all analyses, settings were: $\alpha = 0.05$, 1-tailed test of significance, exponential population change, and CV constant with abundance. We felt our assumption of constant CV was reasonable because sampling error in our abundance estimates has been dominated by variance in encounter rates, which arise from a Poisson-like process.

C.3.3 Results

The CV of process variation was twice as large for KIMU versus MAMU, but uncertainty was high for both species (Table C.1). Lower 90% confidence limits overlapped zero for both species, and upper limits reached very high levels. The magnitude of estimated sampling variance was similar to point estimates of process variation, but resulting CVs for total variation in estimated abundance were strongly influenced by uncertainty in process variation.

Power curves constructed using point estimates of total variation in abundance estimates suggested our objective of >80% power to detect 33% declines over 15 years for both species was feasible (Figure C.1). For both species, we projected high power to detect a steeper decline of 50% over 10 years. However, uncertainty surrounding levels of process variation in abundance introduced similarly large uncertainty in projections of power. For KIMU, the length of the time series needed to achieve 80% power ranged from ~10 to >25 years (Figure C.2). Results were less variable for MAMU, with 80% power projected in ~20 years (Figure C.3). In this scenario, populations at 25 years would have declined by ~50%.

C.3.4 Discussion

Quantifying effects of uncertainty is critical to interpretation of power analyses (Sims et al. 2007). Projections of power using point estimates suggested our design would meet monitoring objectives for both species. However, uncertainty concerning the magnitude of process variation in abundance introduced large imprecision to power projections. For KIMU in particular, uncertainty concerning population variability precluded firm conclusions about whether our sampling design could meet objectives. For both species, we projected relatively high power to detect a steeper decline of 50% over 10 years, suggesting that such “catastrophic” declines could be detected relatively promptly.

Although trend detection capability depends on the combined sources of variation in estimates, performance will be particularly sensitive to process variation in abundance. Even moderate process variation can dramatically reduce power to detect trend, and the only effective remedy is lengthening the time series (Larsen et al. 2001). Large uncertainty in our estimates of process variation resulted from the relatively short times series (5 years) in concert with relatively large sampling error ($\overline{CV} = 0.24$ for KIMU and 0.17 for MAMU; from Drew et al. 2008; Appendix 5) associated with large spatial variation in populations. Hence, precisely quantifying process variance in abundance is unlikely over a short time series. Our 90% CI for process variation (Table C.1) encompassed biologically implausible values (e.g., $\sigma^2 = 0$), and this large uncertainty highlights our limited capacity to project monitoring performance. Recent estimates of abundance for both species been far higher than those during 1999-2003, suggesting populations may be highly variable (Kirchhoff 2008, Kirchhoff et al. 2010, Kirchhoff and Lindell 2011, Hoekman et al. 2013). However, the extent to which results reflect differences in abundance versus in survey methods cannot be fully ascertained (Hoekman et al. 2011).

We did not consider uncertainty in our sampling variances because we had few realizations of abundance estimates using our sampling design. Our estimated sampling variances for 2010-2012 surveys typically were less than from prior surveys in Glacier Bay (e.g., Drew et al. 2008, Kirchhoff 2008), and this increased precision contributed to our more optimistic projections of power to detect decline relative to those by Drew et al. (2008). However, precision of our future estimates will in part depend on unpredictable changes in spatial distributions of populations.

C.4 Summary and Conclusions

Prior monitoring and pilot data can provide valuable information to inform power analyses and to aid in design and assessment of monitoring programs. However, despite substantial prior data, large uncertainty about annual variation in murrelet populations dominated our attempts to assess this monitoring program. Trend detection capability is highly sensitive to annual variation in abundance, and even moderate amounts can require a long time series to effectively estimate trend. Our analyses including uncertainty in this key

parameter suggested potential outcomes ranging from effectively meeting our objective of having ~80% power to detect a 33% decline over 15 years to having to accrue a time series of >25 years to detect such a decline. Capacity to detect shorter, steeper declines was projected to be relatively high.

Abundance estimates using our sampling design have been relatively precise compared to prior surveys, and increased precision should enhance trend detection capability. Power analyses supported the plausibility of meeting our monitoring objectives, but actual performance will largely depend on variability in murrelet populations. We recommend reassessing population variability and monitoring performance at the first 6-year protocol review.

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Appendix C Figures and Tables

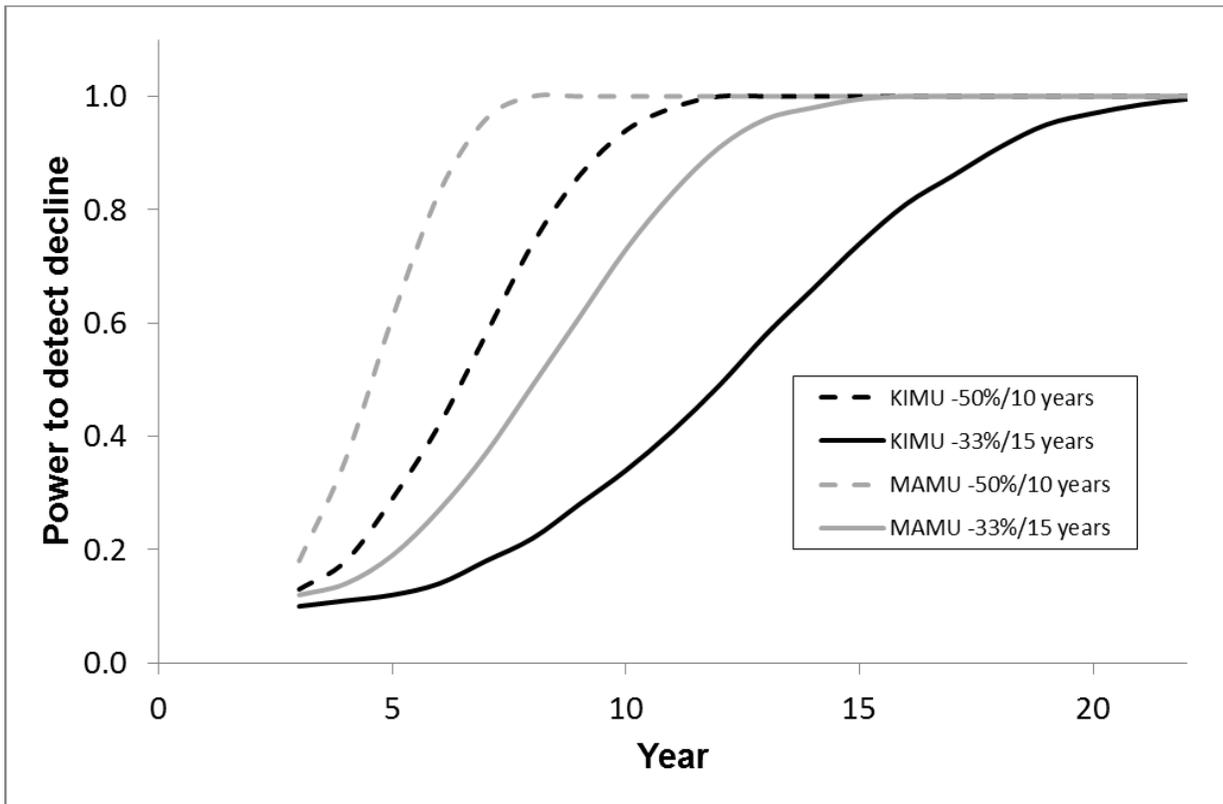


Figure C.1. Estimated power to detect declines in populations of Kittlitz's murrelets (KIMU) and marbled murrelets (MAMU) in Glacier Bay. We considered scenarios of populations declining at rates of 33% over 15 years or 50% over 10 years (2.6% or 6.7% annual declines). Results based on point estimates of total variation in abundance estimates (Table C.1).

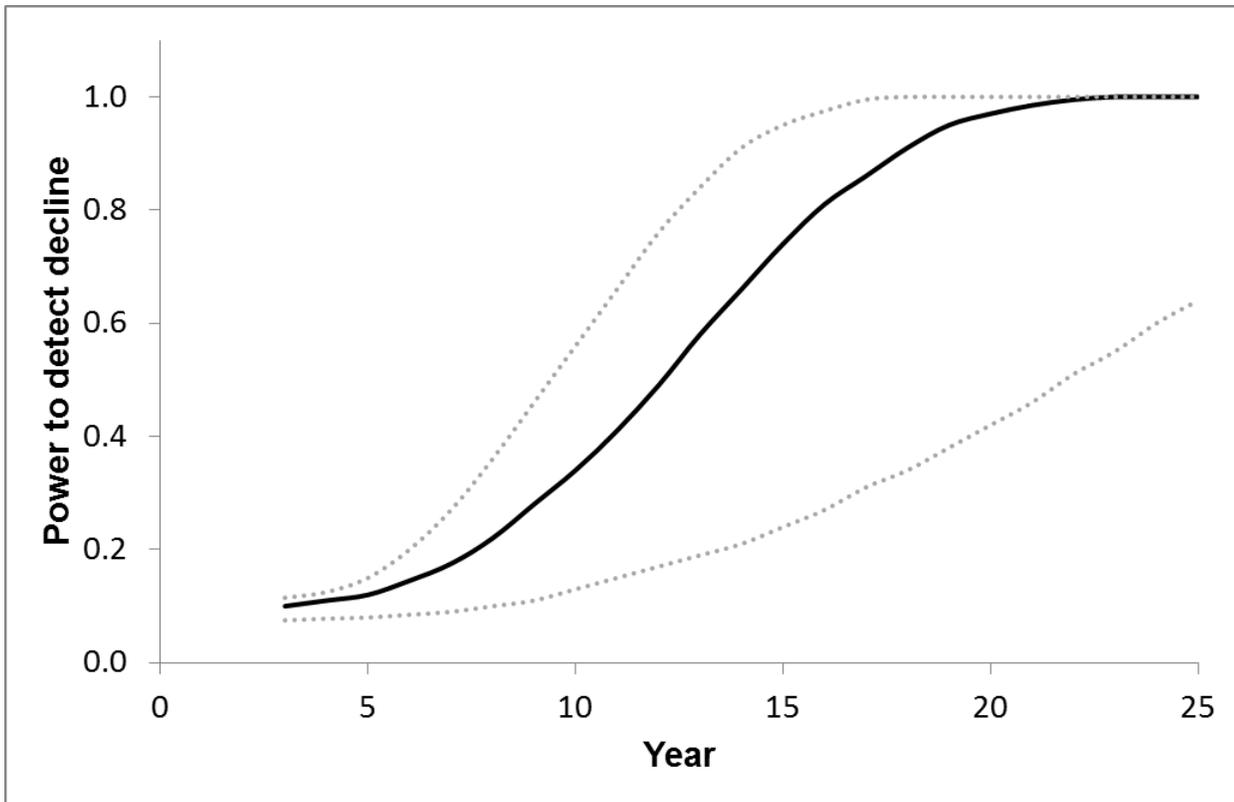


Figure C.2. Estimated power to detect population decline in Kittlitz's murrelets decreasing at a rate of 33% over 15 years. Power was projected using the point estimate of total annual variation in abundance estimates (solid line) and its 90% confidence limits (dotted lines).

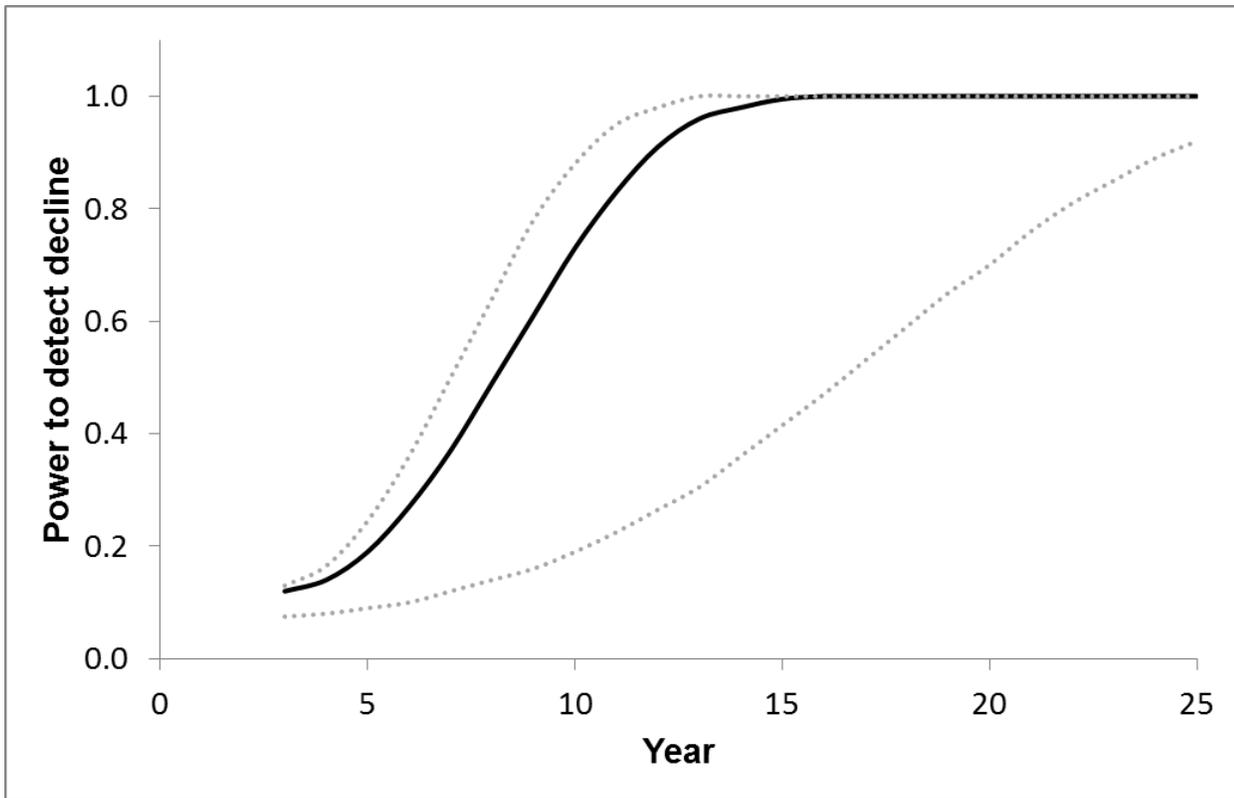


Figure C.3. Estimated power to detect population decline in marbled murrelets decreasing at a rate of 33% over 15 years. Power was projected using the point estimate of total annual variation in abundance estimates (solid line) and its 90% confidence limits (dotted lines).

Table C.1. Coefficients of variation (CV) for process variation, sampling variation, and total variation in estimates of abundance for murrelet populations in Glacier Bay. We quantified uncertainty in process and total variation by estimating 90% confidence limits (CL).

Species	$CV(\hat{\sigma})^a$			$CV\{\overline{\text{var}}(\hat{A}_i A_i)\}^b$	$CV(\hat{A}_i)^c$		
	Lower 90% CL	Point estimate	Upper 90% CL	Point estimate	Lower 90% CL	Point estimate	Upper 90% CL
Kittlitz's murrelet	0.00	0.15	0.49	0.14	0.14	0.20	0.51
Marbled murrelet	0.00	0.07	0.32	0.09	0.09	0.12	0.33

^aCV of between year process variation estimated from Drew et al.(2008).

^bCV of mean sampling variation estimated from Hoekman et al. (2013).

^cCV of total variation in abundance estimates estimated from combined process and sampling variation.

Appendix D: R Computer Code for Population Estimates

Version 1.0

Revision History Log:

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

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# Version 1.0 - R Computer Code for Population Estimates: Encounter rates, adjusted
encounter rates, density, and abundance
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# Notes: Full details of murrelet monitoring in Glacier Bay and for use of this R code are
provided in "Hoekman, S. T., B. J. Moynahan, W. F. Johnson, and C. J. Sergeant. 2013. Glacier
Bay National Park and Preserve Kittlitz's murrelet monitoring protocol: Version KM-2012.1.
Natural Resource Report NPS/SEAN/NRR-2013/735. National Park Service, Fort Collins,
Colorado." Procedures for creating required survey data input files are described in SOP 12:
Abundance Estimation. Analytic methods below are described in Appendix A: Preliminary
Analyses and Analytic Methods. Parts of the code relating to Generalized Random Tessellation
Stratified (GRTS) sampling designs and the local variance estimator are modified from the
spsurvey R package (Kincaid, T. M. and Olsen, A. R. 2012. spsurvey: Spatial Survey Design and
Analysis. R package, version 2.2. URL: <http://www.epa.gov/nheerl/arm>).
```

```
# *****BEGIN USER INPUT*****
# Annual user-defined inputs: In this section, the user specifies inputs relevant to analyses
for each survey year. Typically, altering the files names, file path, and year to reflect the
current survey year are the only required user inputs.
```

```
# Specify full path for folder to contain input and output files.
# *NOTE*: R uses '/' instead of '\' to specify file paths, and path must be in "quotes".
```

```
path<- "//inpglbafs03/data/SEAN_Data/Work_Zone/KM/KM_K/2012/"
```

```
# Specify file names for .csv input files with encounter rate data (as specified in SOP 12,
Table 12.1) and output from Program DISTANCE (as specified in SOP 12, Table 12.2). File name
must be in "quotes".
```

```
Encounter.Rate.file <- "Encounter_rates_2012.csv"
DISTANCE.Output.file <- "Distance_Output_2012.csv"
```

```
# Specify 4-digit survey year. A comma-delimited file with output named "R_Output_YYYY.csv"
(where YYYY is the survey year) will be created in the folder specified above.
```

```
YEAR<-2012
```

```
# Most user-defined inputs below will be invariant among years
```

```
# Desired area for projection of abundance in square km (current survey area is 1,170 km^2)
A<-1170
```

```
# Desired confidence interval coverage for abundance estimates in %
CI<-95
```

```
# Ranges for TRANSECT_ID: set lower/upper limits for each panel
# panels = Number of panels
```

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```
# plim = Lower and upper limits of TRANSECT_ID numbers for each panel ascending from panel 0
panels <- 4
plim <- c(1, 25, 100, 115, 200, 221, 300, 321)

# Min/Max values for latitude and longitude of transect midpoints
# coordlim = min lat, max lat, min lon, max lon
coordlim <- c(58, 59.5, -137.5, -135.5)

# Transect_ID number(s) for survey transects to be excluded from population status estimates
xstatus<- c(16)

# *****LOAD REQUIRED LIBRARIES*****

library(MASS)

# *****BEGIN DATA IMPORT*****

# Import csv files with encounter rate data and DISTANCE output to separate data frames. The
# first 5 rows of each file assumed to contain metadata and are not imported.

ERpath<-paste(path, Encounter.Rate.file ,sep="")
DOPath<-paste(path, DISTANCE.Output.file ,sep="")
ERdata <- read.csv(ERpath, skip = 5)
DOdata <- read.csv(DOPath, skip = 5)

# Define sample weights for transects based on probability of sampling inclusion
ERdata$WEIGHT <- 1/ERdata$P_INCLUD

# Remove transects that were unsampled for current survey year, as indicated by missing
# value for TRANSECT_KM and generate message indicating transects removed

unsampled.row <- c(which(is.na(ERdata$TRANSECT_KM)))
unsampled.row.s <-sort(unsampled.row)

if (length(unsampled.row)>0)
{
  msg<-noquote(paste(length(unsampled.row), "row(s) censored because of missing TRANSECT_ID
values: "))
  print(paste(msg, ERdata$TRANSECT_ID[unsampled.row.s]))
  ERdata <- ERdata[-unsampled.row.s,]
}

# *****BEGIN FUNCTION DEFINITION*****
# These functions carry out various components of analyses and must be loaded prior to
# executing analyses.

# *****FUNCTION checkdata*****

# Checkdata verifies the integrity of dataframe(s) and notifies user of errors relating to:
# null or missing data, data out of specified ranges, data fields of inappropriate type, or
# data fields of differing length

checkdata.func <- function(tempdata)
{
  # Check if data file imported
  if (is.null(tempdata))
    stop("\nD'oh! The data file is null.")

  #Check if data frame is composed of NA (Not Available) values
  if (all(is.na(tempdata)))
    stop("\nThe data file contains no values or cannot be read.")

  # Check if data fields used for ER analyses are numeric
```

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```
nonnumeric <- c(!is.numeric(tempdata$ERK)),
(!is.numeric(tempdata$ERM)), (!is.numeric(tempdata$ERU)), (!is.numeric(tempdata$ERB)),
(!is.numeric(tempdata$TRANSECT_KM)), (!is.numeric(tempdata$LAT_MID)),
(!is.numeric(tempdata$LON_MID)),
(!is.numeric(tempdata$WEIGHT))
if (sum(nonnumeric) >0)
  stop("\nAt least one of the data fields was not the numeric data type.")

# Check if values of encounter rates in field ER fall within defined data range
if (sum(sum(tempdata$ERK<0), sum(tempdata$ERM<0), sum(tempdata$ERU<0), sum(tempdata$ERB<0))
> 0)
  stop("\nValues of ER field must be positive.")

# ~~~~~ CHECK 'OR' OPERATORS

# Check if latitude and longitude values in fields LAT_MID and LON_MID fall within defined
data ranges
coordlim.mat <- matrix(coordlim, nrow=2)
if (!sum(tempdata$LAT_MID<coordlim.mat[1,1]|tempdata$LAT_MID>coordlim.mat[2,1]) == 0)
  stop("\nLatitude values are out of range.")
if (!sum(tempdata$LON_MID<coordlim.mat[1,2]|tempdata$LON_MID>coordlim.mat[2,2]) == 0)
  stop("\nLongitude values are out of range.")
if (!sum(tempdata$WEIGHT<1) == 0)
  stop("\nValues of WEIGHT field must be >=1.")

plim.mat <- matrix(plim, byrow=T, nrow=panels)
if (!sum(tempdata$TRANSECT_ID<plim.mat[1,1]|tempdata$TRANSECT_ID>plim.mat[4,2]) +
sum (for (i in 1:(panels-1)) {
sum(tempdata$TRANSECT_ID>plim.mat[i,2] & tempdata$TRANSECT_ID<plim.mat[i+1,1])) ==0)
  stop("\nTransect_ID values are out of range.")

# Check if fields are same length
if (length(unique(sapply(tempdata, length))) > 1)
  stop("\nComponents in the list passed to the missing value function must be the same
\nlength.")
}

# *****FUNCTION missingdata*****

# Missing data identifies rows with at least one missing value essential to analyses and
returns a data frame with these rows removed. A message indicates transects that are removed
from analyses on account of missing values.

missingdata.func <- function(tempdata)
{
  NArOW <- c(which(is.na(tempdata$TRANSECT_ID)), which(is.na(tempdata$ERK)),
which(is.na(tempdata$ERM)), which(is.na(tempdata$ERU)), which(is.na(tempdata$ERB)),
which(is.na(tempdata$LAT_MID)), which(is.na(tempdata$LON_MID)),
which(is.na(tempdata$WEIGHT)))
  NArOW.s <-sort(NArOW)

  if (length(NArOW)>0)
  {
    data.trim <-ERdata[-NArOW.s,]
    msg<-noquote(paste(length(NArOW), "rows had missing values for fields essential to
analyses. The following transects have been removed from analyses: "))
    print(paste(msg, ERdata$TRANSECT_ID[NArOW.s]))
  }
  if (length(NArOW)==0) {data.trim <- ERdata}

  return(data.trim)
}

# *****FUNCTION geographic.projection*****
```

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```
# This function converts input values from geographic latitude and longitude coordinates
(expressed as decimal degrees) to an equidistant cylindrical projection with units of
kilometers. Latitude and longitude coordinates are derived from the mid-point of each
transect (the center point of a line between the terminal waypoints). The projection is
centered on the mid-point of the latitude/longitude space and assumes an average Earth radius
of 6371 kilometers.
```

```
geographic.projection.func <- function(tempdata)
{
  radius <- 6371
  lat.range <- range(tempdata$LAT_MID)
  lon.range <- range(tempdata$LON_MID)
  lat.mid <- diff(lat.range)/2 + lat.range[1]
  lon.mid <- diff(lon.range)/2 + lon.range[1]
  y.coordinate <- radius * (tempdata$LAT_MID - lat.mid) * pi/180
  x.coordinate <- radius * (tempdata$LON_MID - lon.mid) * pi/180 * cos(lon.mid * pi/180)
  temp <- data.frame(y.coordinate=y.coordinate, x.coordinate=x.coordinate)

  return(temp)
}
```

```
# *****FUNCTION localmean.weighted*****
```

```
# This function calculates estimates of the local, weighted means of the ERs for each species
class (Kittlitz's, marbled, unidentified, Brachyramphus) and also the associated variance-
covariance matrix and SEs and CIs for estimates. The estimator uses a local neighborhood of
4 transects and the sampling weights for each transect. All output is generated using all
survey transects (for population trend analyses) and also for only survey transects selected
using probabilistic methods (for population status analyses).
```

```
localmean.weighted.func<-function(tempdata)
{
  tempdata<-ERdata.trim

  # For population trend estimation, calculate summed weights across all survey transects and
degrees of freedom for estimate of ER mean

  # Calculate weighted mean ER using sampling weights from probabilistic selection (WEIGHT =
1/probability of sampling inclusion) and size weights (TRANSECT_KM = transect length in km)
as well as degrees of freedom for each species class using all transects (for population
trend)
  # 'weightt.sum' is total weight = product of sampling weight and size weight
  # 'ERt.sum' = weighted sum of encounter rates for each species class
  # 'ERt.wmean' = weighted mean encounter rate for each species class

  weightt.sum<-sum(tempdata$WEIGHT*tempdata$TRANSECT_KM) #
  ERt.df<-length(tempdata$WEIGHT)-1
  ERt.mat<-data.frame(ERB=tempdata$ERB, ERK=tempdata$ERK, ERM=tempdata$ERM, ERU=tempdata$ERU)
  ERt.sum<-c(sum(ERt.mat$ERB*tempdata$WEIGHT*tempdata$TRANSECT_KM),
sum(ERt.mat$ERK*tempdata$WEIGHT*tempdata$TRANSECT_KM),
sum(ERt.mat$ERM*tempdata$WEIGHT*tempdata$TRANSECT_KM),
sum(ERt.mat$ERU*tempdata$WEIGHT*tempdata$TRANSECT_KM))
  ERt.wmean<-ERt.sum/weightt.sum

  # Calculate weighted mean ER using weights from probabilistic selection (WEIGHT =
1/probability of sampling inclusion) and size weights (TRANSECT_KM = transect length in km)
as well as degrees of freedom for each species class using probabilistic methods (for
population status)
  # 'weights.sum' is total weight = product of sampling and size weights
  # 'ERs.sum' = weighted sum of encounter rates for each species class
  # 'ERs.wmean' = weighted mean encounter rate for each species class
```

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```
tempdata.trim<-ERdata[-xstatus,] # Trim transects not selected using probabilistic
methods
weights.sum<-sum(tempdata.trim$WEIGHT*tempdata.trim$TRANSECT_KM)
ERs.df<-length(tempdata.trim$WEIGHT)-1
ERs.mat<-data.frame(ERB=tempdata.trim$ERB, ERK=tempdata.trim$ERK, ERM=tempdata.trim$ERM,
ERU=tempdata.trim$ERU)
ERs.sum<-c(sum(ERs.mat$ERB*tempdata.trim$WEIGHT*tempdata.trim$TRANSECT_KM),
sum(ERs.mat$ERK*tempdata.trim$WEIGHT*tempdata.trim$TRANSECT_KM),
sum(ERs.mat$ERM*tempdata.trim$WEIGHT*tempdata.trim$TRANSECT_KM),
sum(ERs.mat$ERU*tempdata.trim$WEIGHT*tempdata.trim$TRANSECT_KM))
ERs.wmean<-ERs.sum/weights.sum

# For all transects, define local neighborhoods for each transect, and weight transects
within each neighborhood using sampling weights (WEIGHT = 1/probability of sampling
inclusion) and using distances between center points for each transect and its neighbors.

# Define neighborhood size (4) and probability of sampling inclusion for transects
n<-length(tempdata$ERK)
neighbors<-4
p.inclusion<-1/tempdata$WEIGHT

# Create indices of nearest neighbors for each transect
index <- apply(as.matrix(dist(cbind(projection$x.coordinate, projection$y.coordinate), diag
= TRUE, upper = TRUE))), 2, order)[1:neighbors, ]

# Make neighborhoods symmetric
neighborhood <- rep(1:n, rep(neighbors, n))
index.temp <- unique(c((neighborhood - 1) * n + index, (index - 1) * n + neighborhood)) - 1
index.sym <- cbind((index.temp)%/%n + 1, (index.temp)%/%n + 1)
index.sym <- index.sym[order(index.sym[, 1]), ]

# Apply linear taper to inverse probability weights and normalize to make true average
index.count <- tabulate(index.sym[, 1])
weight.ij <- numeric(0)
for (i in 1:n) weight.ij <- c(weight.ij, 1 - (1:index.count[i] - 1)/(index.count[i]))
weight.ij <- weight.ij/p.inclusion[index.sym[, 2]]
weight.sum <- sapply(split(weight.ij, index.sym[, 1]), sum)
weight.ij <- weight.ij/weight.sum[index.sym[, 1]]
weight.sum <- sapply(split(weight.ij, index.sym[, 2]), sum)

# Make weights doubly stochastic
# 'weight.ij' gives weight for transect j in neighborhood i
weight.mat <- matrix(0, n, n)
weight.mat[index.sym] <- 0.5
a22 <- ginv(diag(index.count/2) - weight.mat %**% diag(2/index.count) %**% weight.mat)
a21 <- -diag(2/index.count) %**% weight.mat %**% a22
lm <- a21 %**% (1 - weight.sum)
gm <- a22 %**% (1 - weight.sum)
weight.ij <- (lm[index.sym[, 1]] + gm[index.sym[, 2]])/2 + weight.ij

# For all transects, estimate var-covar matrix for ERs of each species class
# 'rv.mat' is a matrix with weighted deviations from the weighted mean for each transect
and species class. Weights are the product of the sampling weights (WEIGHT = 1/probability
of sampling inclusion) and the size weights (TRANSECT_KM = transect length in km).
rv.mat<-matrix(NA, n, 4)

for (i in 1:4)
{
  for (k in 1:n)
  {rv.mat[k,i]<- tempdata$WEIGHT[k] * tempdata$TRANSECT_KM[k] * (ERt.mat[k,i] -
ERT.wmean[i])}
}
```

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```

tot.var<-array(0, c(4, 4))
for (k in 1:4)
  {
    for (l in k:4)
      {
        z1<-rv.mat[,k]
        z2<-rv.mat[,l]
        zb1 <- sapply(split(z1[index.sym[, 2]] * weight.ij, index.sym[, 1]), sum)
        zb2 <- sapply(split(z2[index.sym[, 2]] * weight.ij, index.sym[, 1]), sum)
        tot.var[k, l] <- sum(weight.ij * (z1[index.sym[, 2]] - zb1[index.sym[, 1]]) *
(z2[index.sym[, 2]] - zb2[index.sym[, 1]]))
      }
    if (k > 1) {tot.var[k, 1:(k - 1)] <- tot.var[1:(k - 1), k]}
  }

# 'var.mat' is the estimated variance for each species class using all transects = the sum
of the weighted variances for each neighborhood divided by the sum of the weights.
var.mat<-(tot.var)/(weightt.sum^2)

# For transects selected using probabilistic methods, define local neighborhoods for each
transect, and weight transects within each neighborhood using sampling weights (WEIGHT =
1/probability of sampling inclusion) and using distances between center points for each
transect and its neighbors.

n <- length(tempdata.trim$ERK)
p.inclusion<-1/tempdata.trim$WEIGHT # Define probability of sampling inclusion for
transects
projection<-projection[-xstatus,] # Remove transects not selected using probabilistic
methods

# Create indices of nearest neighbors
index <- apply(as.matrix(dist(cbind(projection$x.coordinate, projection$y.coordinate), diag
= TRUE, upper = TRUE)), 2, order)[1:neighbors, ]

# Make neighborhoods symmetric
neighborhood <- rep(1:n, rep(neighbors, n))
index.temp <- unique(c((neighborhood - 1) * n + index, (index - 1) * n + neighborhood)) - 1
index.sym <- cbind((index.temp)%/n + 1, (index.temp)%%n + 1)
index.sym <- index.sym[order(index.sym[, 1]), ]

# Apply linear taper to inverse probability weights and normalize to make true average
index.count <- tabulate(index.sym[, 1])
weight.ij <- numeric(0)
for (i in 1:n) weight.ij <- c(weight.ij, 1 - (1:index.count[i] - 1)/(index.count[i]))
weight.ij <- weight.ij/p.inclusion[index.sym[, 2]]
weight.sum <- sapply(split(weight.ij, index.sym[, 1]), sum)
weight.ij <- weight.ij/weight.sum[index.sym[, 1]]
weight.sum <- sapply(split(weight.ij, index.sym[, 2]), sum)

# Make weights doubly stochastic
# 'weight.ij' gives weight for transect j in neighborhood i
weight.mat <- matrix(0, n, n)
weight.mat[index.sym] <- 0.5
a22 <- ginv(diag(index.count/2) - weight.mat %**% diag(2/index.count) %**% weight.mat)
a21 <- -diag(2/index.count) %**% weight.mat %**% a22
lm <- a21 %**% (1 - weight.sum)
gm <- a22 %**% (1 - weight.sum)
weight.ij <- (lm[index.sym[, 1]] + gm[index.sym[, 2]])/2 + weight.ij

# For transects selected using probabilistic methods, estimate var-covar matrix for ERs of
each species class
# 'rv.mat' is a matrix with weighted deviations from the weighted mean for each transect
and species class. Weights are the product of the sampling weights (WEIGHT = 1/probability
of sampling inclusion) and the size weights (TRANSECT_KM = transect length in km).

```

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```

rv.mat<-matrix(NA, n, 4)

for (i in 1:4)
{
  for (k in 1:n)
  {rv.mat[k,i]<- tempdata.trim$WEIGHT[k] * tempdata.trim$TRANSECT_KM[k] * (ERs.mat[k,i] -
ERs.wmean[i])}
}

tot.var<-array(0, c(4, 4))
for (k in 1:4)
{
  for (l in k:4)
  {
    z1<-rv.mat[,k]
    z2<-rv.mat[,l]
    zb1 <- sapply(split(z1[index.sym[, 2]] * weight.ij, index.sym[, 1]), sum)
    zb2 <- sapply(split(z2[index.sym[, 2]] * weight.ij, index.sym[, 1]), sum)
    tot.var[k, l] <- sum(weight.ij * (z1[index.sym[, 2]] - zb1[index.sym[, 1]]) *
(z2[index.sym[, 2]] - zb2[index.sym[, 1]]))
  }
  if (k > 1) {tot.var[k, 1:(k - 1)] <- tot.var[1:(k - 1), k]}
}

# vars.mat' is the estimated variance for each species class using transects selected using
probabilistic methods = the sum of the weighted variances for each neighborhood divided by
the sum of the weights.
vars.mat<-(tot.var)/(weights.sum^2)

# Return estimates of ERs, df, and variance-covariance matrices for all transects (for
population trend) and transects selected using probabilistic methods (for population status)
return(c(ERT.wmean, ERT.df, ERs.wmean, ERs.df, vart.mat, vars.mat))
}

# *****FUNCTION ER.adjusted*****

# This function estimates adjusted, species-specific ERs by allocating unidentified groups to
each species assuming the relative occurrence of groups of each species is the same in the
identified and unidentified sample. Variances are estimated from the estimated variance-
covariance matrix using the Delta Method Seber (1982). Confidence intervals are constructed
assuming a minimum approximate degrees of freedom.

ER.adjusted.func<-function(results)
{
  # Build variance-covariance matrix for encounter rates (ER) for each species class
  ERvar.mat<-ER.results[11:26] # Define var-covar matrix from estimated ERs
  dim(ERvar.mat) <- c(4, 4)
  tempvar.mat <- ERvar.mat[-1,-1]

  # Estimate adjusted ER for each species
  ER.vec<-results[2:4]
  ERadj<-c(NA, NA)
  for (i in 1:2) {ERadj[i]<-(ER.vec[i]+(ER.vec[i]/sum(ER.vec[1:2]))*ER.vec[3])}

  # Estimate sampling variances using Delta Method
  # Calculate first partial derivatives of each ER with respect to each adjusted ER
  ER.derivatives<-c(rep( NA, 6))
  dim(ER.derivatives) <- c(2, 3)
  ER.diff<-c(rep(NA, 6))
  dim(ER.diff) <- c(2, 3)

  for (i in 1:2) # Loop for species-specific ERs
  {
    for (j in 1:3) # ER loop for each species class

```

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```

    {
      ERtemp.vec<-ER.vec
      ERtemp.vec[j]<-ER.vec[j]+0.0000000001
      ER.diff[i,j]<-(ERtemp.vec[i]+(ERtemp.vec[i]/sum(ERtemp.vec[1:2]))*ERtemp.vec[3]) -
ERadj[i]
    }
  }
  ER.derivatives<-ER.diff/0.0000000001

# Multiple derivatives by var-covar matrix to estimate variance of adjusted ERs
ERadj.var <- c(NA, NA)
temp<-c(rep(NA, 3))
ER.derivativesT <- t(ER.derivatives)
for (i in 1:2)
  {
    temp<- ER.derivatives[i,] %*% tempvar.mat
    ERadj.var[i]<-temp %*% ER.derivativesT[,i]
  }

# Use minimum estimate of degrees of freedom df
ERadj.df<-c(results[1:2,5,1])

# Estimate confidence limits for adjusted ERs
ERadj.CL<-array(NA, c(2, 2))
for (i in 1:2)
  {
    mult<-qnorm(0.5+(CI/100/2))
    ERadj.CL[i,1]<-ERadj[i]-mult*ERadj.var[i]^0.5
    ERadj.CL[i,2]<-ERadj[i]+mult*ERadj.var[i]^0.5
  }

# Return list with means, sampling variances, confidence limits (CL), and minimum
approximate degrees of freedom (df) for adjusted ERs
return(c(ERadj, ERadj.var, ERadj.CL, ERadj.df))
}

# *****FUNCTION density.plus*****

# This function estimates species-specific density per km^2 and abundance across the user-
defined extent of the study area. Input combines estimates of adjusted encounter rates (ER)
for each species produced above and several estimates from prior analyses: w (truncation
distance for transect observations in m), Pa (detection probability across the transect width
w), Pc (detection probability near the transect center line), and group size (for each
species class; K=Kittlitz's murrelet, M=marbled murrelet, U=unidentified murrelet).
Variances are estimated using the Delta Method, and user-specified confidence limits are
constructed using a z-distribution. Approximate degrees of freedom are calculated for density
and abundance using methods of Satterthwaite (1946). All analyses are carried out both for
analyses of population trend (using all transects) and population status (using transects
selected using probabilistic methods).

density.plus.func <- function(DOdata, results, status)

{
  alpha = 1 - (CI/100) # Calculate alpha from user-specified confidence interval

# Import estimates and associated values from analyses in Program DISTANCE

Pa <- DOdata$Pa           # detection probability across the transect width w
Pa.se <- DOdata$Pa_SE     # SE{detection probability} across the trasect width w
Pa.df <- DOdata$Pa_DF     # df for detection probability across the trasect width w
Pc <- DOdata$Pc           # detection probability near the transect center line
Pc.se <- DOdata$Pc_SE     # SE{detection probability} near the transect center line
Pc.df <- DOdata$Pc_DF     # df for detection probability near the transect center line
w<-DOdata$W/1000          # the trasect width w

```

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```
ER<-results[2:4,1,1]      # estimated encounter rates for each species class
ERadj<-results[2:3,1,2]  # species-specific encounter rates, adjusted for unidentified
murrelets

# Import values specific to population status analyses

if (status)
{
  S<-c(DOdata$SKS, DOdata$SMS, DOdata$SUS) # Group sizes for (K)IMU, (M)AMU, (U)NMU
  # 'SI' is group size for identified murrelets = weighted avg of S(K) + S(M)
  SI<-S[1]*(ER[1]/sum(ER[1:2]))+S[2]*(ER[2]/sum(ER[1:2]))
  S<-c(S, SI) # Group sizes for (K)IMU, (M)AMU, (U)NMU, (I)dentified murrelets
  S.se<-c(DOdata$SKS_SE, DOdata$SMS_SE, DOdata$SUS_SE) # SEs of group sizes
  S.df<-c(DOdata$SKS_DF, DOdata$SMS_DF, DOdata$SUS_DF) # df for group sizes
}

# Import values specific to population trend analyses

else
{
  S<-c(DOdata$SKT, DOdata$SMT, DOdata$SUT) # Group sizes for (K)IMU, (M)AMU, (U)NMU
  # 'SI' is group size for identified murrelets = weighted mean of S(K) + S(M)
  SI<-S[1]*(ER[1]/sum(ER[1:2]))+S[2]*(ER[2]/sum(ER[1:2]))
  S<-c(S, SI) # Group sizes for (K)IMU, (M)AMU, (U)NMU, (I)dentified murrelets
  S.se<-c(DOdata$SKT_SE, DOdata$SMT_SE, DOdata$SUT_SE) # SEs of group sizes
  S.df<-c(DOdata$SKT_DF, DOdata$SMT_DF, DOdata$SUT_DF) # df for group sizes
}

# Estimate mean density for each species
c=S[3]/S[4]
density.km<-c(rep(NA, 2))

for (i in 1:2)
{
  # Estimate species-specific group size adjusting unidentified groups
  Sadj<-S[i]*(ER[i]/ERadj[i])+c*S[i]*(ERadj[i]-ER[i])/ERadj[i]
  # Estimate species-specific density (individuals/km^2) using adjusted group size,
  # adjusted ER, detection probability, and transect width.
  density.km[i] <- (Sadj*ERadj[i])/(Pa*Pc*2*w)
}

# Construct var-covar matrix for all component parameters of density estimates
ERvar.mat<-ER.results[11:26] # Define var-covar matrix for ERs from prior estimates
dim(ERvar.mat) <- c(4, 4)
# 'tempvar.mat' is matrix with variances for K, M, and U species classes
tempvar.mat <- ERvar.mat[-1,-1]

# Define var-covar matrix for all estimates. Covariances can only be estimated between ERs
varcov<-array(0, c(8,8))

for (i in 1:3)
{
  for (j in 1:3)
  {
    varcov[i,j]<-tempvar.mat[i,j] # Var-covar for each species class
  }
}

for (i in 4:6)
{
  varcov[i, i]<-S.se[i-3]^2 # Var of group size for each species class
}
varcov[7,7]<-Pa.se^2 # Var for Pa
varcov[8,8]<-Pc.se^2 # Var for Pc
```

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Calculate first partial derivatives for each component parameter with respect to density estimates for each species.

```

D.derivatives <- c(rep( NA, 16))
dim(D.derivatives) <- c(2, 8)
D.diff <- c(rep(NA, 16))
dim(D.diff) <- c(2, 8)
ERadj.tmp <- c(NA, NA) # Adjusted encounter rates for K and M
Sadj.tmp <- c(NA, NA, NA) # Adjusted group size for K, M, and I
D.tmp<-c(rep(NA, 16))
dim(D.tmp) <- c(2, 8)

for (i in 1:2) # Loop for species: K and M
{
  for (j in 1:8) # Loop for component parameters
  {
    par.vec<-c(ER, S[-4], Pa, Pc)
    partemp<-par.vec
    partemp[j]<-par.vec[j]+0.0000000001 # Perturb one component parameter
    for (k in 1:2) # Species loop again to recalculate adj ER and S for each species
    {
      ERadj.tmp[k]<-(partemp[k]+partemp[3]*(partemp[k]/(sum(partemp[1:2]))))
      c.tmp<-
partemp[6]/((partemp[4]*(partemp[1]/(sum(partemp[1:2]))))+partemp[5]*(partemp[2]/(sum(partemp
[1:2]))))
      Sadj.tmp[k]<-partemp[i+3]*(partemp[i]/ERadj.tmp[i])+c.tmp*partemp[i+3]*
((ERadj.tmp[i]-partemp[i])/ERadj.tmp[i])
    }
    # 'D.tmp' = density with perturbed parameter, 'D.diff' = Perturbed - original density
    D.tmp[i,j]<- (Sadj.tmp[i]*ERadj.tmp[i])/(partemp[7]*partemp[8]*2*w)
    D.diff[i,j]<- (Sadj.tmp[i]*ERadj.tmp[i])/(partemp[7]*partemp[8]*2*w) - density.km[i]
  }
}
# 'D.derivatives' is a vector of first partial derivatives, obtained by dividing
differences in perturbed densities by the magnitude of perturbation
D.derivatives<-D.diff/0.0000000001

# Multiply derivatives^2 by var-covar matrix of component parameters to estimate variance
of density estimates

density.var <- c(NA, NA)
temp<-c(rep(NA, 8))
D.derivativesT <- t(D.derivatives)
for (i in 1:2)
{
  temp<- D.derivatives[i,] %*% varcov
  density.var[i]<-temp %*% D.derivativesT[,i]
}

# Estimate degrees of freedom (df) for density estimates using Satterthwaite approximation
and minimum degrees of freedom for adjusted encounter rates and exact df for other parameters

density.df<-c(NA, NA)
for (i in 1:2) # Loop for species K and M
{
  temp<-c(rep(0, 4))
  temp[1]<-((results.trend[i+1,3,2]^0.5/ERadj[i])^4)/results[i+1,5,2] # Term for species-
specific adjusted ER

  for (j in 1:3) # Loop for group size for K, M, and U species
  {
    temp[j+1]<-((varcov[j+3,j+3]^0.5/S[j])^4/S.df[j])
  }
}

```

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```
density.df[i]<-(density.var[i]^0.5/density.km[i])^4/(sum(temp) + ((Pa.se/Pa)^4/Pa.df) +
((Pc.se/Pc)^4/Pc.df))
}

# Construct user-specified confidence limits (CL) for density estimates using a log-based
estimator and the z-distribution

density.CL<-array(NA, c(2, 2))
for (i in 1:2)
{
density.CL[i,1]<-density.km[i] *
exp(qnorm(alpha/2)*(log(1+density.var[i]/density.km[i]^2))^0.5)
density.CL[i,2]<-density.km[i] /
exp(qnorm(alpha/2)*(log(1+density.var[i]/density.km[i]^2))^0.5)

# If lower CL is <0, use one-sided confidence interval
if(density.CL[i,1]<0)
{
density.CL[i,1]<-0
density.CL[i,2]<-density.km[i] /
exp(qnorm(alpha)*(log(1+density.var[i]/density.km[i]^2))^0.5)
}
}

# Project species-specific abundance across user-defined survey area

abundance<- c(NA, NA)
for (i in 1:2)
{
abundance[i]<-density.km[i]*A
}

# Calculate variance estimates for species-specific abundances

abundance.var<-c(NA, NA)
for (i in 1:2)
{
abundance.var[i]<-density.var[i]*A^2
}

# Estimate degrees of freedom (df) for abundance estimates using Satterthwaite
approximation with minimum df for adjusted encounter rates and exact df for other component
parameters

abundance.df<-c(NA, NA)
for (i in 1:2) # Loop for species K and M
{
temp<-c(rep(0, 4))
temp[1]<-((results.trend[i+1,3,2]^0.5/ERadj[i])^4)/results[i+1,5,2] # Term for species-
specific adjusted ER

for (j in 1:3) # Loop for group size for K, M, and U species
{
temp[j+1]<-((varcov[j+3,j+3]^0.5/S[j])^4/S.df[j])
}
abundance.df[i]<-(density.var[i]^0.5/density.km[i])^4/(sum(temp) + ((Pa.se/Pa)^4/Pa.df)
+ ((Pc.se/Pc)^4/Pc.df))
}

# Construct user-specified confidence limits (CL) for abundance estimates using a log-based
estimator and a z-distribution
```

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```
abundance.CL<-array(NA, c(2, 2))
for (i in 1:2)
{
  abundance.CL[i,1]<-abundance[i] *
exp(qnorm(alpha/2)*(log(1+abundance.var[i]/abundance[i]^2))^0.5)
  abundance.CL[i,2]<-abundance[i] /
exp(qnorm(alpha/2)*(log(1+abundance.var[i]/abundance[i]^2))^0.5)

  # If lower CL<0, use one-sided confidence interval

  if(abundance.CL[i,1]<0)
  {
    abundance.CL[i,1]<-0
    abundance.CL[i,2]<-abundance[i] /
exp(qnorm(alpha)*(log(1+abundance.var[i]/abundance[i]^2))^0.5)
  }
}

# Return list of estimated densities per km^2 and abundances over user-specified area with
associated variances, confidence limits (CL), and degrees of freedom (df)

return(c(density.km, density.var, density.CL, density.df, abundance, abundance.var,
abundance.CL, abundance.df))
}

# *****END FUNCTION DEFINITION*****

# *****BEGIN ANALYSIS EXECUTION*****

# Check integrity of data frame (ERdata) with imported ER data
checkdata.func(ERdata)

# Check for and remove rows in ER data frame (ERdata) with at least one missing value among
essential fields. Return dataframe (ERdata.trim) with these rows trimmed.
ERdata.trim<-missingdata.func(ERdata)

# Convert decimal degrees latitude/longitude coordinates in trimmed ER data frame
(Erdata.trim) to equidistant projection in data frame (projection)
projection<-geographic.projection.func(ERdata.trim)

# Create arrays for results from population trend and population status analyses
results.trend<-rep(NA, 112)
dim(results.trend)<-c(4,7,4)
dimnames(results.trend) <- list(c("Brachyramphus", "Kittlitz's", "Marbled", "Unidentified"),
c("Estimate", "SE", "var", "n", "df", paste("Lower ",CI, "% CL", sep=""), paste("Upper ",CI,
"% CL", sep="")), c("Encounter Rates", "Adjusted Encounter Rates", "Density", "Abundance"))
results.status<-rep(NA, 112)
dim(results.status)<-c(4,7,4)
dimnames(results.status) <- list(c("Brachyramphus", "Kittlitz's", "Marbled", "Unidentified"),
c("Estimate", "SE", "var", "n", "df", paste("Lower ",CI, "% CL", sep=""), paste("Upper ",CI,
"% CL", sep="")), c("Encounter Rates", "Adjusted Encounter Rates", "Density", "Abundance"))

# Estimate weighted mean encounter rates (ER) and degrees of freedom (df) for each species
using all transects (for use in population trend analyses) and transects selected using
probabilistic methods (for use in population status analyses). Append estimates to results
array.

ER.results<-localmean.weighted.func(ERdata.trim)
ERvar.mat<-ER.results[11:26] # Define variance-covariance matrix for population trend
analyses
dim(ERvar.mat) <- c(4, 4)
```

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```
ERvars.mat<-ER.results[27:42]      # Define variance-covariance matrix for population status
analyses
dim(ERvars.mat) <- c(4, 4)

# Append ER estimates to population trend results
results.trend[,1,1]<-ER.results[1:4]      # ERs for all Brachyramphus murrelets and each
species class (K, M, U)
results.trend[,5,1]<-ER.results[5]        # df for ERs
results.trend[,4,1]<-ER.results[5]+1      # n for ERs
results.trend[,2,1]<-(diag(ERvars.mat))^0.5 # SEs for ERs
results.trend[,3,1]<-diag(ERvars.mat)     # Sampling variance for ERs

# Append ER estimates to population status results
results.status[,1,1]<-ER.results[6:9]     # ERs for all Brachyramphus murrelets and each
species class (K, M, U)
results.status[,5,1]<-ER.results[10]      # df for ERs
results.status[,4,1]<-ER.results[10]+1    # n for ERs
results.status[,2,1]<-(diag(ERvars.mat))^0.5 # SEs for ERs
results.status[,3,1]<-diag(ERvars.mat)    # Sampling variance for ERs

# Append confidence limits (CL) to ERs using user-specified confidence interval (CI) and z-
distribution
mult<-qnorm(0.5+(CI/100/2))
for (i in 1:4)
{
  results.trend[i,6,1]<-ER.results[i]-ERvars.mat[i,i]^0.5*mult # Lower CL of ERs for trend
analyses
  results.trend[i,7,1]<-ER.results[i]+ERvars.mat[i,i]^0.5*mult # Upper CL of ERs for trend
analyses
  results.status[i,6,1]<-ER.results[i]-ERvars.mat[i,i]^0.5*mult # Lower CL of ERs for status
analyses
  results.status[i,7,1]<-ER.results[i]+ERvars.mat[i,i]^0.5*mult # Upper CL of ERs for status
analyses
}

# Estimate adjusted ER and associated variances and CLs for population trend analyses and
append to results

ERadj.results <- ER.adjusted.func(results.trend)

results.trend[2:3,1,2]<-ERadj.results[1:2]      # Species-specific adjusted ERs for K and
M
results.trend[2:3,2,2]<-(ERadj.results[3:4])^0.5 # SE of species-specific adjusted ERs
results.trend[2:3,3,2]<-ERadj.results[3:4]      # Sampling variance of species-specific
adjusted ERs
results.trend[2:3,6,2]<-ERadj.results[5:6]      # Lower CL for species-specific adjusted
ERs
results.trend[2:3,7,2]<-ERadj.results[7:8]      # Upper CL for species-specific adjusted
ERs
results.trend[2:3,5,2]<-ERadj.results[9:10]     # Approximated df for species-specific
adjusted ERs
results.trend[2:3,4,2]<-results.trend[2:3,4,1]  # n for adjusted ERs

# Estimate adjusted ER and associated variances and CLs for population status analyses and
append to results

ERadj.results <- ER.adjusted.func(results.status)

results.status[2:3,1,2]<-ERadj.results[1:2]     # Species-specific adjusted ERs for K and
M
results.status[2:3,2,2]<-(ERadj.results[3:4])^0.5 # SE of species-specific adjusted ERs
results.status[2:3,3,2]<-ERadj.results[3:4]     # Sampling variance of species-specific
adjusted ERs
```

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```
results.status[2:3,6,2]<-ERadj.results[5:6]           # Lower CL for species-specific adjusted
ERs
results.status[2:3,7,2]<-ERadj.results[7:8]           # Upper CL for species-specific adjusted
ERs
results.status[2:3,5,2]<-ERadj.results[9:10]          # Approximated df for species-specific
adjusted ERs
results.status[2:3,4,2]<-results.status[2:3,4,1]      # n for adjusted ERs

# Adjusted group sizes, density, abundance, and associated df and error terms for population
trend and population status analyses

# Estimate species-specific density and abundance (across user-specified area) for population
trend analyses using estimates of adjusted encounter rates and prior estimates of detection
probability and group size.

density.results <- density.plus.func(DOdata, results.trend, 0)

# Append species-specific estimates of density (individuals/km^2) and abundance and
associated df and error terms for population trend analyses to results table

results.trend[2:3,1,3]<-density.results[1:2]          # Density estimates for K and M
results.trend[2:3,2,3]<-(density.results[3:4])^0.5   # SE{density}
results.trend[2:3,3,3]<-density.results[3:4]          # var{density}
results.trend[2:3,6,3]<-density.results[5:6]          # Lower CL for densities
results.trend[2:3,7,3]<-density.results[7:8]          # Upper CL for densities
results.trend[2:3,5,3]<-density.results[9:10]          # Approximated df for density

results.trend[2:3,1,4]<-density.results[11:12]        # Abundance estimates for K and M
results.trend[2:3,2,4]<-(density.results[13:14])^0.5 # SE{abundance}
results.trend[2:3,3,4]<-density.results[13:14]          # var{abundance}
results.trend[2:3,6,4]<-density.results[15:16]          # Lower CL for abundance
results.trend[2:3,7,4]<-density.results[17:18]          # Upper CL for abundance
results.trend[2:3,5,4]<-density.results[19:20]          # Approximated df for abundance

# Estimate species-specific density and abundance (across user-specified area) for population
status analyses using estimates of adjusted encounter rates and prior estimates of detection
probability and group size.

density.results <- density.plus.func(DOdata, results.status, 1)

# Append species-specific estimates of density (individuals/km^2) and abundance and
associated df and error terms for population status analyses to results table

results.status[2:3,1,3]<-density.results[1:2]          # Density estimates for K and M
results.status[2:3,2,3]<-(density.results[3:4])^0.5   # SE{density}
results.status[2:3,3,3]<-density.results[3:4]          # var{density}
results.status[2:3,6,3]<-density.results[5:6]          # Lower CL for density
results.status[2:3,7,3]<-density.results[7:8]          # Upper CL for density
results.status[2:3,5,3]<-density.results[9:10]          # Approximated df for density

results.status[2:3,1,4]<-density.results[11:12]        # Abundance estimates for K and M
results.status[2:3,2,4]<-(density.results[13:14])^0.5 # SE{abundance}
results.status[2:3,3,4]<-density.results[13:14]          # var{abundance}
results.status[2:3,6,4]<-density.results[15:16]          # Lower CL for abundance
results.status[2:3,7,4]<-density.results[17:18]          # Upper CL for abundance
results.status[2:3,5,4]<-density.results[19:20]          # Approximated df for abundance

# Output results of density and abundance analyses to R console and .csv files.

# Print results for population trend and status analyses to R console

print("Estimates for Population Trend Analyses")
print(round(results.trend, digits=2))
```

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```
print("Estimates for Population Status Analyses")
print(round(results.status, digits=2))

# Define output file path using user-specified import/export folder and file name using user-
specified survey year.

OUTPUTpath<-paste(path,"R_Output_",YEAR,".csv", sep="")

# Define matrix OUTPUT to hold population trend and status results for export

OUTPUT<-rep(NA, 352)
dim(OUTPUT)<-c(32,11)
dimnames(OUTPUT)<-list(NULL, c("SURVEY_YEAR", "ANALYSIS_CODE", "ATTRIBUTE_CODE",
"SPECIES_CODE", "ESTIMATE", "SE", "VAR", "N", "DF", paste("CL_LOWER_", CI,"_PCT", sep=""),
paste("CL_UPPER_", CI,"_PCT", sep=""))) # Assign field names
OUTPUT[,1]<-YEAR # Define survey year
OUTPUT[1:16,2]<-"TREND" # ANALYSIS_CODE: Rows containing results for analyses of
population trend
OUTPUT[17:32,2]<-"STATUS" # ANALYSIS_CODE: Rows containing results for analyses of
population status
COL3<-c("Encounter.Rate", "Adjusted.Encounter.Rate", "Density", "Abundance") # ATTRIBUTE_CODE
COL4<-c("Brachyramphus", "Kittlitzs", "Marbled", "Unidentified") # SPECIES_CODE

# Insert estimates for population trend analyses into output matrix

for (i in 1:4) # Attribute_code loop
{
  for (j in 1:4) # Species_code loop
  {
    OUTPUT[(i-1)*4+j,3]<-COL3[i] # Assign attribute_code
    OUTPUT[(i-1)*4+j,4]<-COL4[j] # Assign species_code
    for (k in 1:7) # Estimates loop
    {
      OUTPUT[(i-1)*4+j,k+4]<-results.trend[j,k,i] # Assign estimate value
    }
  }
}

# Insert estimates for population status analyses into output matrix

for (i in 1:4) # Attribute_code loop
{
  for (j in 1:4) # Species_code
  {
    OUTPUT[(i+3)*4+j,3]<-COL3[i] # Assign attribute_code
    OUTPUT[(i+3)*4+j,4]<-COL4[j] # Assign species_code
    for (k in 1:7) # Estimates loop
    {
      OUTPUT[(i+3)*4+j,k+4]<-results.status[j,k,i] # Assign estimate value
    }
  }
}

# Remove rows without estimates

miss.rows<-which(is.na(OUTPUT[,5]))
OUTPUT<-OUTPUT[-miss.rows,]

# Write results for population trend and status analyses to a .csv file in the user-specified
output folder. The na= argument specifies how missing data are output.

write.csv(OUTPUT, OUTPUTpath, row.names = FALSE, na="")
```

Appendix E: Standard Form Templates

Version 1.0

Revision History Log:

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

Electronic copies of all standard forms are available at the following web site:

http://science.nature.nps.gov/im/units/sean/KM_Main.aspx. They may be accessed using the “KM Data Toolbox” link under the Original Source Data tab.

E.3 SEAN KIMU Distance Calibration Trials: Session Sergeant Record



**SEAN KIMU DISTANCE CALIBRATION TRIALS
SESSION SERGEANT RECORD**

Sergeant: _____
Initials

Date: _____
Including year

Start/End Time: _____ / _____
ADT

Observers: _____
Initials, Initials

Objects: _____
Description of training objects

Session type: Training Assessment

Beaufort: _____
(0) Calm (1) 1-20 cm (2) 20-50 cm (3) 0.5-1 m (4) 1-2 m

Weather: _____
(0) <50 CC (1) >50 CC (2) Fog (3) Mist (4) Rain

Visibility: _____
(1) > 500m (2) 250-500m (3) < 250m

Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9	Trial 10
1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9	9

Distance to nearest meter

Notes:

Appendix F: NPTransect-KIMU Survey Tool

Version 1.0

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
	November 2012	R. Sarwas	Initial version		1.0

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F.1 Introduction

The NPTransect-KIMU survey tool is a custom ArcGIS Mobile project which assists in the data collection for murrelet inventories in Glacier Bay National Park. It uses a GPS device to continuously track the location of the survey crew and the location and details of each bird group observation. Field data is synchronized with a fully relational ArcGIS file geodatabase, and can be exported to a CSV file for archival and analysis by third parties. The data collection protocol utilizes angle and distance to locate each bird group relative to the centerline of the boat.

ArcGIS Mobile is a customizable ESRI product for collecting field data on mobile devices (in this case a laptop computer) and synchronizing the mobile data with a master GIS database (in this case also on the laptop computer).

F.2 Installation

F.2.1 Prerequisites

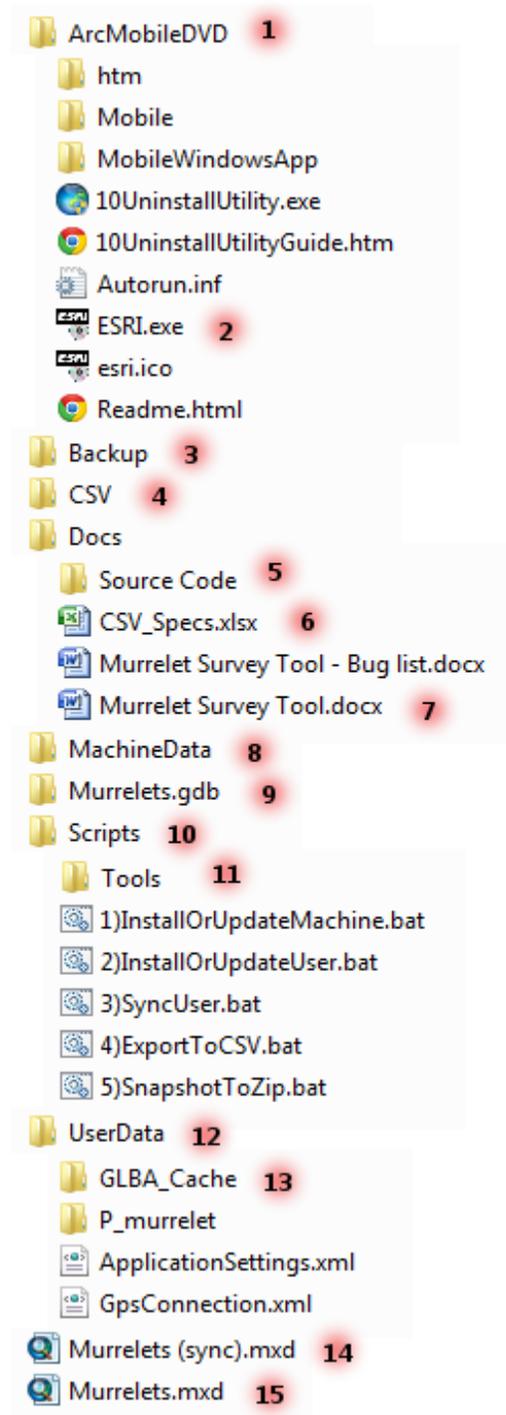
- 1) Laptop with 64 bit Windows 7 Enterprise Edition installed¹.
- 2) ArcGIS Desktop 10+ installed with a standalone license for ArcEditor or ArcInfo.
- 3) Ability to receive NMEA sentences from your GPS device on your laptop's COM port. See F.2.5 Configuring the GPS for details.

¹Other configurations may work, but have not been tested.

F.2.2 Project Folder Structure

Everything else required for using NPTransect-KIMU is installed in the C:\KIMU folder. The contents of this folder may be copied from one computer to another, or installed from one or more ZIP files. Once correctly installed, the contents of the C:\KIMU folder will look like the following:

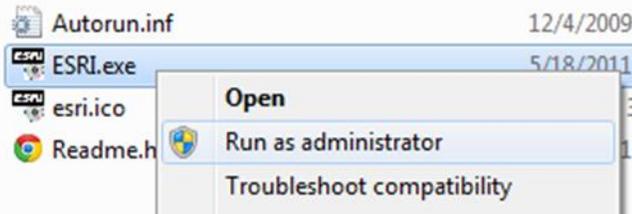
- 1) The contents of the ArcGIS Mobile installation DVD.
This folder is about 100MB in size and may be delivered as a separate ZIP file.
- 2) Double click this program to install ArcGIS Mobile on the laptop.
- 3) This folder contains a ZIP file for every day that script 5 is run. Each ZIP file contains a current copy of items 4 and 9 and is named by the day it ran.
- 4) This folder contains the CSV export file.
- 5) The computer code used to create this application.
- 6) The specification for the CSV file in item 4.
- 7) Help document.
- 8) A folder containing the application files that must be administratively installed in the systems folders. This is done by script 1.
- 9) The file geodatabase containing the master copy of the project data. This database is described in the F.5 Database Schema section.
- 10) A folder of the automation scripts. These scripts are described later in this document.
- 11) The tools folder contains programs used by the scripts and does not need to be accessed directly.
- 12) This folder contains files that will be copied to the data recorder's profile. These files are copied by script 2.
- 13) Background imagery. This folder is about 1GB in size and may be delivered as a separate ZIP file.
- 14) The ArcMap document used for syncing item 9 and the data recorder's mobile cache. This document defines the look of the data in the application.
- 15) This ArcMap document is used for viewing and editing the project data, see the section F.4 Editing in ArcMap for more info.



There should only ever be one copy of C:\KIMU\Murrelet.gdb as the master database. If two copies are used concurrently, data will be fragmented and difficult to merge. It is the user's responsibility to maintain control of the master copy of C:\KIMU\murrelet.gdb.

F.2.3 Installing ArcGIS Mobile

- 1) Right click the file C:\KIMU\ArcMobileDVD\ESRI.exe and select Run as administrator



- 2) Select Setup for ArcGIS Mobile on the splash screen

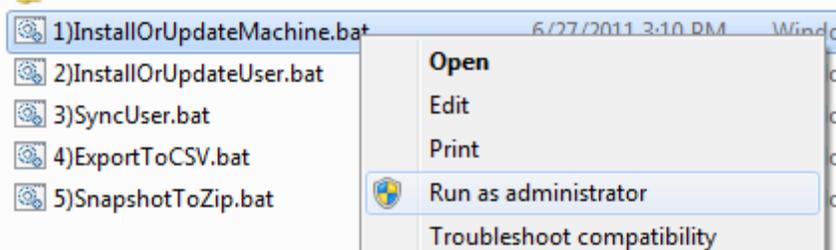
ArcGIS Mobile 10 (Build 2500)



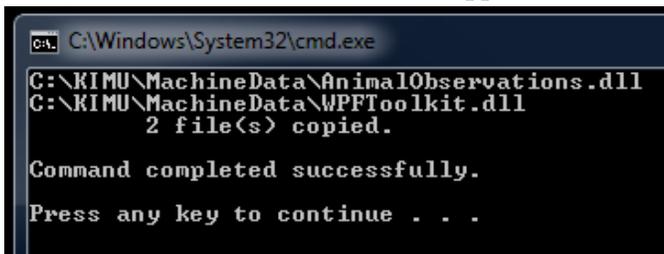
- 3) Select all the installation defaults until finished.

F.2.4 Configuring NPTransect-KIMU

- 1) Right click the file C:\KIMU\Scripts\1)InstallOrUpdateMachine.bat and select Run as administrator



- 2) A command window should appear with the following message



- 3) Close the window by clicking the close button.

- 4) The following steps need to be done by the data recorder. If you are not the data recorder, you should have them login to complete the following steps, or if you know the data recorder's credentials, you can shift right click on the files specified in the steps below and select Run as different user to run them as the data recorder.
- 5) Double click the file C:\KIMU\Scripts\2)InstallOrUpdateUser.bat
- 6) A command window should appear displaying the progress of several copy/sync operations. In the end it should look similar to the following:

```

C:\Windows\system32\cmd.exe
100%      New File           81952      R3280C5000.bundlex
          New Dir           1         C:\KIMU\UserData\P_murrelet\
100%      New File           3283      murrelet.amp
          New Dir           0         C:\KIMU\UserData\P_murrelet\MobileCache\

-----
          Total      Copied      Skipped      Mismatch      FAILED      Extras
 Dirs  :          13          12           1             0             0             0
 Files :          53          53           0             0             0             0
 Bytes : 1016.98 m 1016.98 m           0             0             0             0
 Times :    0:00:29    0:00:29             0             0             0             0

Speed  :          36127778 Bytes/sec.
Speed  :          2067.248 MegaBytes/min.

Ended  : Wed Jun 29 11:26:15 2011
# Syncing mobile map schema
# Reading: C:\KIMU\Murrelets (sync).mxd
# Writing: C:\Users\resarwas\AppData\Local\ESRI\ArcGIS Mobile\P_murrelet

Command completed successfully.
Press any key to continue . . .
    
```

- 7) Close the window by clicking the close button.
- 8) Double click the file C:\KIMU\Scripts\3)SyncUser.bat
- 9) A command window should appear with a similar message.

```

C:\Windows\system32\cmd.exe
# Syncing mobile map data
# Master Map: C:\KIMU\Murrelets (sync).mxd
# Mobile Cache: C:\Users\resarwas\AppData\Local\MobileCache
Press any key to continue . . .
    
```

- 10) Close the window by clicking the close button.

F.2.5 Configuring the GPS

The GPS device you use must be configured to output NMEA sentences. The following instructions explain how to do this on a Garmin GPSmap 76CSx

- 1) Press the menu button twice
- 2) Use the center button to highlight the Setup option then press the enter button
- 3) Use the center button to highlight the Interface option then press the enter button
- 4) In the Serial Data Format pick list select NMEA In/NMEA Out
- 5) Press Quit button 3 times to return to main screen

The GPS device you use must be configured to use true north when reporting the bearing. The following instructions explain how to do this on a Garmin GPSmap 76CSx

- 1) Press the menu button twice
- 2) Use the center button to highlight the Setup option then press the enter button
- 3) Use the center button to highlight the Heading option then press the enter button
- 4) In the North Reference pick list select True
- 5) Press Quit button 3 times to return to main screen

The GPS device you use must be configured to use WGS 84 as the map datum. The following instructions explain how to do this on a Garmin GPSmap 76CSx

- 1) Press the menu button twice
- 2) Use the center button to highlight the Setup option then press the enter button
- 3) Use the center button to highlight the Units option then press the enter button
- 4) In the Map Datum pick list select WGS 84
- 5) Press Quit button 3 times to return to main screen

To connecting the GPS to a laptop, there are three main options depending on the GPS and the laptop. Exact details need to be worked out based on the available hardware. There are three main options.

- 1) If the laptop has a serial COM port (9 pin), and the GPS device has a serial cable then plug the serial cable into the com port.
- 2) If the GPS device has a serial cable, but the laptop only has a USB port, you can buy a USB serial port adaptor (aka port replicator). Plug the serial cable from the GPS into the port adaptor, and plug the port adaptor into the USB on the laptop.
- 3) If the GPS device only has a USB cable. Plug the USB cable into the USB port on the laptop, and install and turn on a virtual COM port driver. A free option is Franson GPSGate (http://gpsgate.com/products/gpsgate_client)

F.2.6 Changing Laptops in Mid-mission

Should you choose to switch laptops for some reason during a single field season, the following instructions will get a new laptop set up and ready to collect data.

- 1) Ensure that all data recorders have run script 3)SyncUser.bat on the old laptop.
- 2) Follow all the instructions for setting up a new laptop.
- 3) Replace the C:\KIMU\murrelet.gdb folder and contents on the new laptop with the same folder and contents from the old laptop.
 - a. If the old laptop is unavailable, then extract this C:\KIMU\murrelet.gdb from the most recently available backup file (originals are created in C:\KIMU\Backup, and should be available on a backup device)
 - b. If the modified copy of C:\KIMU\murrelet.gdb from the original laptop is currently unavailable, you can either

- i. Start with an empty version (installed by default), and have a GIS specialist merge the old and new versions of C:\KIMU\murrelet.gdb once the mission is complete. If the old version of C:\KIMU\murrelet.gdb is permanently lost, then you need to plead with a GIS specialist to recreate the original data from the last CSV export.
- ii. If there are no backups, or part of the work is missing from the most recent backup, then you either need to resurvey the missing work, or forgo that data.

F.2.7 Changing Data Recorders in Mid-mission

The instructions in this section assume that the laptop has not changed, if it has, see F.2.6 Changing Laptops in Mid-mission. It also assumes that the laptop was fully setup for data recording by a previous data recorder, if not, see F.2 Installation. To change the data recorder follow these instructions.

- 1) Login to the laptop as the new data recorder
- 2) Run the script C:\KIMU\Scripts\3)SyncUser.bat by double clicking it from windows explorer.
- 3) Start ArcGIS Mobile from the start menu (All Programs -> ArcGIS -> ArcGIS Mobile -> ArcGIS Mobile).

The new data recorder will not see any data (track logs, observations, etc.) collected since the last time that the previous data recorder ran script 3)SyncUser.bat. In addition, CSV files and backups created by the new data recorder will also not contain that data. (Hopefully As soon as the previous data recorder can run script 3)SyncUser.bat, the missing data will be available for CSV export and backup, and the new data recorder will see it in the mobile map as soon as they rerun script 3)SyncUser.bat. It is important to remember the following:

- 1) Data collected by one data recorder is only in their personal cache (not C:\KIMU\murrelet.gdb until script 3)SyncUser.bat is run.
- 2) Only the user that collected the data (or someone with that person's password) can synchronize their cache.
- 3) Script 3)SyncUser.bat Is a two way synchronization. It updates your personal cache with new data in C:\KIMU\murrelet.gdb and updates C:\KIMU\murrelet.gdb with new data from your personal cache.
- 4) The synchronization can be done by any user at any time. Synchronization does not need to be done in the order the data was collected.

F.3 Operation

F.3.1 Yearly Configuration

Each year the transects that should appear in NPTransect will be different than the year before, and most likely, the data recorder will not want to see data collected in previous years. To accomplish this use the following procedure:

- 1) Open the file C:\KIMU\Murrelets (sync).mxd in ArcMap.
- 2) For each item in the table of contents:
 - a. Double click the item or right click and select Properties...
 - b. Select the Definition Query tab
 - c. Edit the definition query to select the appropriate data for the coming year
- 4) Save and Close ArcMap.
- 5) Have each data recorder run C:\KIMU\Scripts\2)InstallOrUpdateUser.bat and then C:\KIMU\Scripts\3)SyncUser.bat.

In addition, each year you should verify that the clock and the time zone on the laptop are set correctly. The time zone is used to GPS time to local time.

F.3.2 Daily Operation

The following is a summary of the steps performed by the data recorder each day. Details are in F.3.3 Data Collection Details. The following steps can be repeated more often than every day. To ensure better coverage of the data on the backup devices, you could repeat these step as often as every transect.

- 1) Run C:\KIMU\Scripts\3)SyncUser.bat to ensure that your mobile cache and the master database are in sync. This first step will almost always be redundant and can usually be skipped. If you aren't sure, then just do it. It can't hurt to do it more often than required.
- 2) Turn on the GPS
- 3) Start the ArcGIS Mobile application
- 4) Collect data, see F.3.3 Data Collection Details.
- 5) Stop Recording
- 6) Close ArcGIS Mobile
- 7) Run C:\KIMU\Scripts\3)SyncUser.bat to push the newly collected data into the master database.
- 8) Run C:\KIMU\Scripts\4)ExportToCSV.bat to create C:\KIMU\CSV\2011.csv, where 2011 will change based on the current year.
- 9) Run C:\KIMU\Scripts\5)SnapshotToZip.bat to create C:\KIMU\Backup\2011-06-29.zip where the file name will change to reflect the current date (if this step is done more than once per day, the older file is overwritten).
- 10) Copy the ZIP file created in the previous step to one or more backup devices.

See the section on F.6.2 Script Details in the F.6 Miscellaneous section for additional information on the scripts, specifically when they should be run, and conditions that may cause an error.

F.3.3 Data Collection Details

F.3.3.1 Initial Map Page

When the application starts, it should look something like the following:



If the GPS device is on, receiving a signal, and you are within Glacier Bay, then the application should pan to your location and draw a boat icon at your current location. If you do not see the boat, make sure the GPS device is on, and then try to reconnect as described below.

The application should automatically try and connect to the GPS, however if this option was turned off, or if the GPS was not on when the application started, then you must manually connect to the GPS by clicking on the satellite button and selecting Connect to GPS.



F.3.3.2 Moving Around the Map

The map will automatically pan when the boat gets close to an edge of the map, however if you want to pan manually, simply use the mouse to click and drag the map. Be aware, that if you pan the boat too close to the edge of the map while the GPS is connected, the map will soon ignore your pan in order to put the boat back in the center. Disconnect the GPS if you wish to explore the map.

You can zoom in/out with the scroll wheel on the mouse, or the scroll bar on the laptop trackpad. You can



also use the Buttons to zoom in/out respectively.



Other map viewing options are available with the button. These options are seldom required, and largely self-explanatory. If you need additional help, please consult the ArcGIS Mobile help.

F.3.3.3 Start Task

To start the task, first zoom out until the transect you are going to collect is within view (presumably you are already close to it), then click the blue Tasks button and select Collect Observations.



The other two other available tasks (Identify and Measure) are not used in this application. If you want to know more about using them, please consult the ArcGIS Mobile help.

If there the GPS is not connected, or there is no GPS signal the task will fail to start with the following error message:



If there is no transect in the view, then the task will fail to start with the following error message:



F.3.3.4 Track Log Setup

Once the task starts successfully, you will be presented with the following data entry screen:

The screenshot shows the 'Track Log Setup' interface within the 'ArcGIS Mobile - KIMU Survey Tool'. The title bar includes a duck icon and the text 'Track Log Setup' with the subtitle 'Enter information common to pending observations'. The form contains the following fields:

- Transect:** A dropdown menu with 'MainBay19' selected.
- Vessel:** An empty text input field.
- Data Recorder:** An empty text input field.
- Observer #1:** An empty text input field.
- Observer #2:** An empty text input field.
- Protocol ID:** An empty text input field.
- Weather:** A dropdown menu with '0: <50% Cloud cover' selected.
- Visibility:** A dropdown menu with '1: >500 m' selected.
- Beaufort:** A dropdown menu with '2: Light breeze 3-7 km/h; 20-50 cm, Few whitecaps' selected.
- On Transect:** An unchecked checkbox.

At the bottom of the form, there are two buttons: a white 'Back' button on the left and a green 'Start Recording' button on the right.

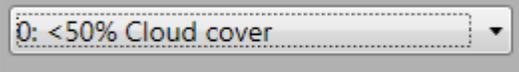
The transect pick list will be limited to only those transects that are within the map view. This list will update every time this page is reloaded. The default transect will be one closest to the boat when this page was loaded. In a given session, this form will remember values, so as you stop and start track logs you will only need to enter the information that has changed. The form will not remember your previous values when you quit the application.

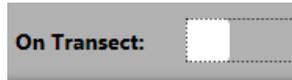
The form will always have valid (although not always useful) values, so you can start recording at any time by clicking the green Start Recording button, or pressing the enter key.

To cancel the task and go back to the initial map page, click the Back button, or press the escape key.

Keyboard Navigation

The application was designed to require minimal mouse input. The form on this page can be navigated using the keyboard shortcuts discussed below. When the cursor is in a text box then that text box has focus, and any keyboard entry will go into that text box. If a pick list or check box has keyboard focus then it is outline

with a light gray dashed line, as shown here:  and



To move from field to field, use the tab key to go to the next field, use shift-tab to go to the previous field. Pressing tab at the bottom of the page will take you back to the top, and pressing shift tab at the top of the page will take you back to the bottom.

To go to a specific field use the Alt key plus the underlined letter of the field you wish to navigate directly to.

For example, when you press the Alt key, the letter W in Weather is underlined.  If you press the W key while the Alt key is depressed the cursor will move to the Weather field. Each field has a keyboard shortcut that is revealed while pressing the Alt key.

Escape at any time will take you back to the initial map page.

Enter at any time will take you to the next screen and start recording the track log. Enter will not advance you from one field to the next (that is the job of the tab key). Remember not to press the enter key until you are ready to start recording.

When keyboard focus is on a pick list, you can switch the select item by using the arrow key, or entering the first character(s) of the displayed text. Note that keys in quick succession will be interpreted as one word, so you can differentiate pick list items that have similar beginnings. As a consequence typing 1-2 will select not select the item starting with 1 then the item starting with 2. It will look for the item starting with '12', and not finding it will select the closest match, the item starting with 1. To start a new selection, just introduce a short (1 second) pause between characters. If you want to see all the items in the pick list at once, press the F4 key. When the full list is displayed, you can use tab/shift-tab, the arrow keys and the initial characters to move the focus around the list. To finalize your selection and dismiss the list, press the enter key.

When keyboard focus is on a check box, the space bar will toggle the option on/off.

When focus is in a text field, the all of the standard editing shortcuts (ctrl x/c/v for cut copy and paste, ctrl-z for undo, ctrl-a for select all, etc.) work as expected.

F.3.3.5 Record Track Log



When the Record Track Log page appears, the application starts recording GPS points every 2 seconds. These points appear on the screen as blue dots. It also creates a trail (or track) based on those points which it draws in red. It will continue tracking your location until you click the red 'Stop Recording' button, (or press the escape key). From this screen, you can change the Weather, Visibility, Beaufort, and On Transect flag at any time. If need to change any other track log attributes, you will need to stop recording, make the change on the Track Log setup page, and then click the start recording button on that page.

The Weather, Visibility, and Beaufort pick lists and the On Transect check box follow all the same keyboard navigation shortcuts discussed in the previous section.

You cannot begin making observations until you are on transect. It is a good idea to leave the On Transect check box cleared on the Track Log Setup page (It is off by default). Then when you start recording you can see the relationship of the boat to the transect. The data recorder can then assist the pilot in navigating the boat to the start of the transect. When the boat is at the beginning of the transect, the data recorder can toggle On Transect to checked, and clear the observers to begin.



You can use the same map navigation feature discussed in the previous section, however in general once you have set an appropriate zoom level, the map screen will follow the boat, and you will not need to do any manual map navigation.

When an observer calls in an observation, click the Green 'New Observation' button, or press the enter key. The application will immediately place an observation on the most recently collected GPS Point, and change to the Edit Observation Attributes Page. The application uses the most recent GPS Point, because it is on average 1 second old (between 0 and 2 seconds), and that is a reasonable estimate for the amount of time that elapsed between the observer making the observation, and the data recorder recording the observation. To try and be anymore exact would require too much communication and potentially introduce unbounded errors.

F.3.3.6 Make Observations

When the data recorder clicks the Green 'New Observation' button, or presses the enter key in the Track Log Recording Page, the application switches to the Edit Observation Attributes Page which initially looks like the following.

ArcGIS Mobile - KIMU Survey Tool

Observation at 8:38:22 AM
Edit the observation values

Angle:

Distance:

Bird Groups:

Group Size	Behavior	Species	Comment
0	Pending	Pending	

*Distance must be a positive integer.
GroupSize must be positive and less than 100, Behavior cannot be Pending*

Cancel New Observation Save

At this point the data recorder will typically enter the observation information. If the observer wishes to cancel or retract the observation (perhaps the birds were not murrelets), the data recorder can press the escape key or click the red 'Cancel' button to delete the current unfinished observation and return to the previous page (either the Record Track Log Page, or another observation as discussed below).

The application will not let you save an observation until the observation is valid. When the observation is invalid, the Save button is grayed out, and there is a red error message on the page, explaining what is wrong. For an observation to be valid it must meet the following criteria:

- Angle must be an integer between 0 and 360 inclusive
- Distance must be a positive integer less than 500
- There must be at least one bird group
- Each bird group must be valid, a valid bird group is one in which
 - The group size is a positive integer less than 100
 - The behavior is not pending

There can be any number of bird groups associated with an observation, and the grid will expand to accommodate them. To start a new bird group, simple tab or arrow to the empty row at the bottom of the grid, and enter a group size. This will create a new bird group, and add a new blank line to the bottom of the grid. If you want to remove a bird group from an observation, select the entire row and press the delete key.

Once there is a valid observation, then the Save button will go from gray to green and the observation can be saved. To save the observation, click the green save button, or press Ctrl-S. The enter key is not a reliable shortcut for saving the observation (see the section on keyboard navigation for more information). When the observation is saved, the active observation will be closed and you will be presented with the previous page.

The screenshot shows the 'Observation at 8:38:22 AM' screen in the ArcGIS Mobile - KIMU Survey Tool. The interface includes a title bar with a duck icon and the text 'Edit the observation values'. Below the title bar, there are two input fields: 'Angle:' with the value '170' and 'Distance:' with the value '50'. A table labeled 'Bird Groups:' contains one row with the following data:

Group Size	Behavior	Species	Comment
4	Water	Marbled	

At the bottom of the screen, there are three buttons: a red 'Cancel' button, a blue 'New Observation' button, and a green 'Save' button.

In most cases, the previous page is the Track Log Recording page, however you may have multiple active observation, so the previous page may be the Edit Observation Attributes Page with a different open observation.

It is not important to close an observation immediately. The application will continue to track the location of the boat and record GPS points and the track in the background. You may wish to leave an observation open for an indeterminate amount of time until the observer can positively determine the species. If either observer makes a new observation while there is an unfinished observation, the data recorder has two choices.

- 1) If the observation is valid (species = pending is valid) then the observation can be saved, and when the Record Track Log screen reappears, then press the green 'New Observation' button to begin the new observation. If the data recorder needs to update the first observation, for example to update the

species, they can select the observation for editing from the Record Track Logs Page as discussed below in the section on editing.

- 2) Regardless of the validity of the observation the data recorder can always click the blue 'New Observation' button, or press the Ctrl-N key combination. This will put the active observation in the background, and open a new observation just as if the observation had been made from the Record Track Log page. The Edit Observation Attributes page will look like the following:

*Distance must be a positive integer.
GroupSize must be positive and less than 100, Behavior cannot be Pending*

Group Size	Behavior	Species	Comment
0	Pending	Pending	

Unfinished Observations: 8:38:22 AM 8:40:36 AM

Buttons: Cancel, New Observation, Save

The open observations are identified by the time they were made. The time of the observation you are working on is in the title of the page. It is also highlighted in the list of unfinished observations at the bottom of the page.

To switch between observations, either use the mouse to click any of the times (observations) in the unfinished observations list, or use the keyboard navigation discussed below.

As open observations are saved, they disappear from the list of unfinished observation, or if a new observation is made, it is added to the list. There is no limit to the number of open unfinished observations. Nevertheless, observations should be saved and closed as soon as possible to avoid confusion, and possible errors.

Once all active observations are finished (Saved or Canceled), the application will return to the Record Track Log Page.

Keyboard Navigation

Keyboard navigation is the same is basically the on the Setup Track Log Page, except the grid is a little more of a pain.

To tab into or out of the bird group data grid, use ctrl-tab and ctrl-shift-tab

Enter key in the data grid closes editing on the current row and advances to the next row.

The row is in view mode, no editing allowed, until a key is pressed in the group size or comment field, or a mouse click is received in either of the pick lists. Once the row is in edit mode, pick list behavior will be as described in the Setup Track Log Page.

Changes in the Angle or Distance fields are not saved until you leave the field with a tab or mouse click. Changing the Angle or Distance and then pressing enter or clicking the Save button will not save the new value.

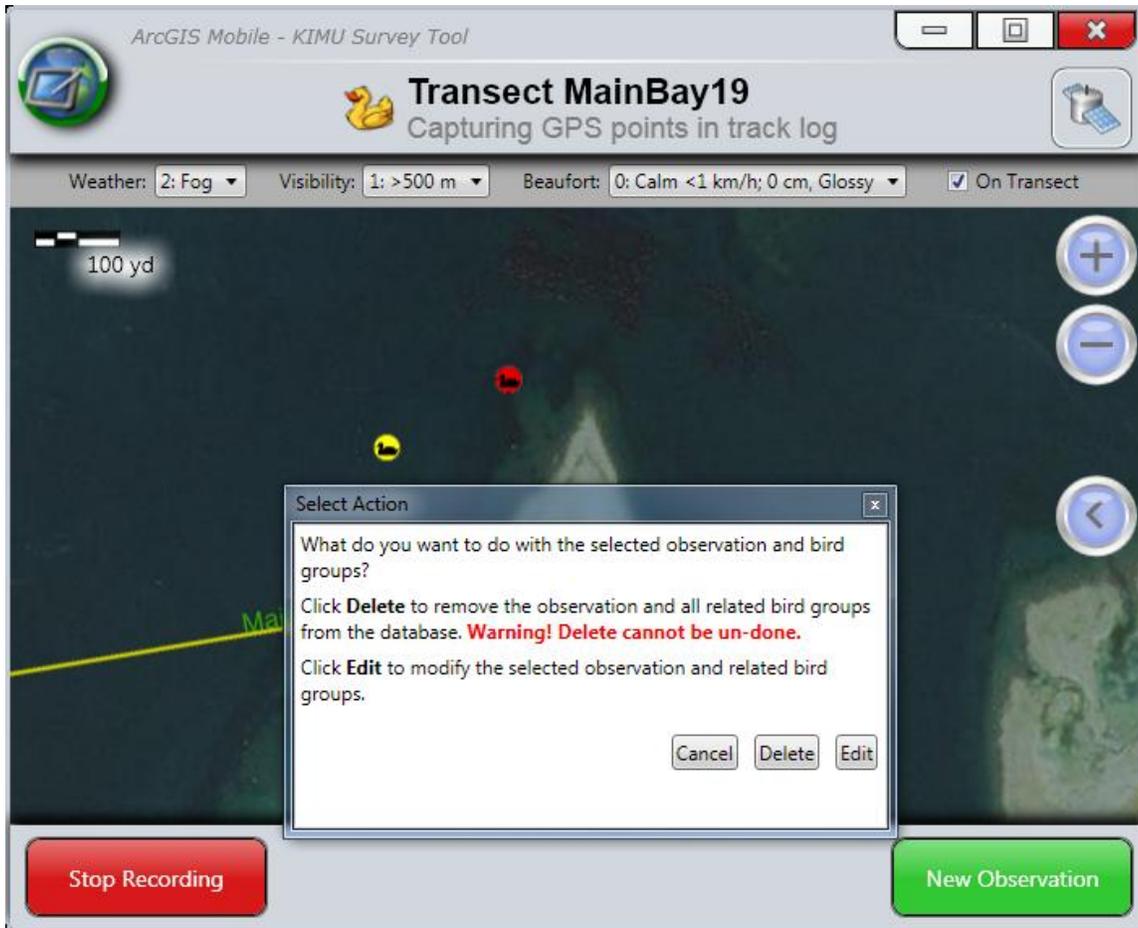
F.3.3.7 Edit or Delete Observations

Once you have observation, they will appear on the Record Track Log page in the correct location.

Observations will be light green dots at a GPS point, and the bird groups will be bird icons. The bird icons are colored as follows:

- Red = Pending
- Purple = unidentified species
- Yellow = Kittlitz's murrelets
- Green = marbled murrelets
- If there are more than one bird groups in an observation, only the color of the top group will be shown. The top group is not specified.

From the Record Track Log page, you can deleted observations (and all related bird groups), or edit an observation, to include changing or deleting any of the related bird groups. To edit or delete a bird group or observation, click on the bird group or observation. Clicking on an observation will automatically select the related bird groups, and clicking on a bird group will automatically select the observation and all other related bird groups. When you have clicked on a bird group, the following dialog box will appear asking if you want to edit or delete the observation/bird group. You can also select cancel if you accidentally clicked on a bird group or observation.



If you click Delete, the observation and all related bird groups will be removed from the screen and delete from the database without any further action. You cannot undo this action, and all record of where that observation occurred is lost. If you click edit, the Edit Observation Attributes page will open, and you will be able to edit the observation as discussed in the previous section.

F.3.3.8 Miscellaneous Notes

Closing the application at any time will save any open observations and track logs (an observation cannot be saved if it is not valid) before closing.

If the application loses connectivity with the GPS (for example, cable disconnects, batteries die, GPS is turned off, etc.), then the application will save any open observations and track logs (an observation cannot be saved if it is not valid), and return to the starting page.

F.4 Editing in ArcMap

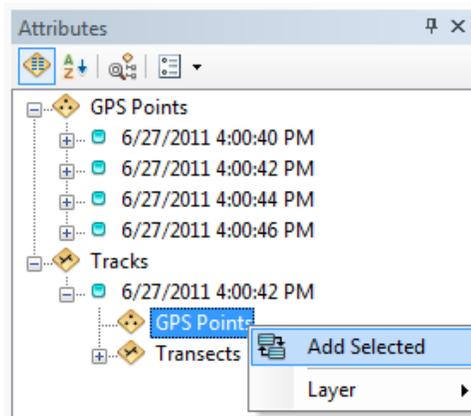
It is possible to make minor corrections to the data in ArcMap at the end of the day. These changes should occur after running script C:\KIMU\Scripts\3)SyncUser.bat and before running script C:\KIMU\Scripts\4)ExportToCSV.bat. In general, this document assumes you know how to edit data in ArcMap, so this section only contains details on the highlights that are unique to the data in this application.

Use caution when editing project data in ArcMap. If the relationships are not properly maintained, then it may be that the save cannot be committed until the relationships are corrected, or it may be that the save will commit, but incorrect results will be reported in the CSV export.

- 1) Open C:\KIMU\Murrelets.mxd in ArcMap
- 2) Start editing.
- 3) Transects
 - a. Should never be edited.
 - b. In particular, never deleted or rename a transect, as they are referenced by name by track logs
- 4) Tracks
 - a. Any of the non-spatial attributes can be edited, i.e., transect, weather, on/off transect, etc.
 - b. Deleting a track is permissible, but not advised. It is better to mark a track as off transect. If you delete a track then all related GPS points, observation and bird groups also need to be deleted. ArcMap should do the cascading delete for you (my observation is that if you a save edits first the cascading delete is successful, however if there are unsaved edits, then the cascading delete does not happen correctly). If ArcMap does not delete related records, then you must do so manually.
 - c. If you want to change attributes on only a portion of a track, you split the track into two tracks:
 - i. Use the line split tool to split a track into two tracks. Turn on snapping, so that the split happens at a vertex (GPS point). Do not split the track at a vertex that has an observation.
 - ii. Select only the track that will get the new attribute, and change the attributes as needed.
 - iii. Adjust the start and end time of the two tracks, so that the appropriate value matches the time of the GPS point at the split point. Copy and paste the local time of the GPS point. Note that the start and end times of the tracks are based on the laptop clock not the GPS time, so they may not match the GPS points exactly. It is not critical the time on the tracks is exact, as it is only used for sorting the tracks.
 - iv. Give the modified segment a new ID.
 1. In the fields tab of the Tracks layer properties, make the Global ID and Track ID fields visible.
 2. Select the modified track
 3. Copy and paste the value of the Global ID to the Track ID
 - v. Duplicate the GPS point at the intersection of the two tracks. This is the point where the split was made. The new GPS point will be related to the modified track, whereas the original GPS point will be related to the unmodified track. The easiest way to do

this is with copy/paste. You may need to save edits after the paste in order for the results to correctly display.

- vi. Change the GPS Point ID of the new GPS point using the same process used for the changing the track's track ID
- vii. Relate the GPS points to the correct track log.
 1. Select the modified track and all the GPS points touching the track, be sure to select one (but only one) at each end.
 2. In the attributes view, browse to the GPS Points under the selected track, right click and select **Add Selected** as shown here:



3. You may need to save edits before the results will display correctly.

5) GPS Points

- a. GPS points should never be edited, except as required when splitting a track.
- b. Do not move GPS points, this will cause the spatial location and the attribute location (lat/long) to be out of sync, and incorrect values will be reported in the CSV file.
- c. Do not create new GPS points, except as required when splitting a track.

6) Observations

- a. If either of the non-spatial attributes, i.e., angle or distance, must be edited then the related bird groups must be moved. See the instructions for editing Bird Groups.
- b. You can delete an observation. ArcMap should (but does not always) delete the related bird groups. Before deleting an observation, identify the related bird groups, so that you can verify that they are also deleted. If ArcMap does not delete them for you, then delete the related bird groups manually.
- c. Adding a new observation
 - i. An observation can only be created at an existing GPS point. To avoid possible confusion, it is best to not create observations at the intersection of two tracks.
 - ii. Turn on snapping so that the new observation is always added on top of an existing GPS point.
 - iii. Relate the observation to the GPS point using the method described for relating GPS points to a track.
 - iv. Edit the Angle and Distance attributes.
 - v. Create 1 or more new bird groups at the correct angle and distance. See the following section for details.

7) Bird Groups

- a. Any of the non-spatial attributes, i.e., group size, species, behavior or comments can be easily edited.
 - b. Deleting a bird group is permitted, however if you delete the last bird group related to an observation, then you must also delete the observation point.
 - c. Moving a Bird Group
 - i. If you move a bird group, you must move all the bird groups related to an observation, and you must adjust the angle and/or distance attributes of the related observation
 - ii. Move the bird group to the related observation. Hint use snapping.
 - iii. Get the value of bearing field for the GPS point related to the observation, and the angle of the observation, hint select the bird group and use the attributes view to browse to the related data.
 - iv. Add the angle to the bearing and then subtract 180 (an angle of 180 is dead ahead, i.e., the boat bearing), and write this number down on a scratch pad along with the distance in the observation
 - v. Select **Options...** in the Editor menu (on the Editor toolbar), and on the **Units** tab, ensure that the **Direction Type** is set to **North Azimuth**.
 - vi. Create a new (temporary) track by snapping the first point to the related observation, and create the second point at the appropriate angle/distance (use ctrl-G or right click for the context menu).
 - vii. Move the bird group(s) to the end of the new temporary track
 - viii. Delete the temporary track.
 - d. Creating a new bird group
 - i. All bird groups must be related to an existing observation. Create an observation first if necessary.
 - ii. All bird groups must be located at the angle and distance specified in the related observation
 - iii. If this is a new bird group for an existing observation, then create the new bird group on top (use snapping) of the existing bird group(s) for that observation, if not then create the new bird group in the vicinity of the related observation.
 - iv. Edit the attributes (group size, species, behavior, comments) as appropriate
 - v. Related the bird group to the related observation using the method described for relating GPS points to a track.
 - vi. Move the bird group to the correct position if necessary.
- 8) Stop editing, save edits if prompted.
- 9) Close ArcMap without saving changes to the document.

F.5 Database Schema

The project data is stored in an ESRI file geodatabase (C:\KIMU\Murrelets.gdb). There are five feature classes that store all the project data. These feature classes are in a Feature Class Dataset called UTM8 that enforces a projection of UTM 8N (NAD83 Datum) on all the feature classes. The feature classes are related to each other as follows:

- 1) Each **bird group** has exactly one related observation; multiple bird groups may be related to the same observation.
- 2) Each **observation** has exactly one related GPS point. There should never be more than one observation related to a given GPS point. Each observation should have at least one bird group related to it.
- 3) Each **GPS point** has exactly one related Track. There should be exactly one related GPS point at each vertex of each track. (There will be two GPS points where the ends of two adjacent tracks meet, one related to each of the tracks.)
- 4) Each **track** has exactly one related transect. Multiple tracks may be related to the same transect.
- 5) A **transect** may have zero or more tracks related to it.

The requirements identified by the word should with an underline are enforced by the application not the file geodatabase. These relationships can become corrupted with improper editing in ArcMap.

F.5.1 Transects Feature Class

Column	Data Type	Notes
ObjectID	Integer(32bit)	Managed by GIS; see note below
GlobalID	Guid	Managed by GIS; see note below
Shape	Blob	Managed by GIS; only editable with spatial tools
Shape_Length	Double	Managed by GIS; not editable; length of the transect
TransectID	Text(20)	Name of the transect
Sample	Integer(16bit)	Sampling interval 1=permanent panel, sampled annually, 2 through 4=panels sampled on a 3-year rotation, 2=2010, 2013, ..., 3=2011, 2014,... 5=alternate transects to be used if primary transects can't be sampled
XOffset	Integer(16bit)	Provided by Steve Hoekman (used by him for labeling)
YOffset	Integer(16bit)	Provided by Steve Hoekman (used by him for labeling)
Angle	Integer(16bit)	Provided by Steve Hoekman (used by him for labeling)

F.5.2 Tracks Feature Class

Column	Data Type	Notes
ObjectID	Integer(32bit)	Managed by GIS; see note below
GlobalID	Guid	Managed by GIS; see note below
Shape	Blob	Managed by GIS; only editable with spatial tools
Shape_Length	Double	Managed by GIS; not editable; length of the track
TrackID	Guid	Primary key, assigned by application, or when editing in ArcMap
TransectID	Text(20)	Foreign key to TransectID column in Transect Feature Class
Vessel	Text(12)	Name of the vessel
Recorder	Text(12)	Name of the data recorder
Observer1	Text(12)	Name of the first observer
Observer2	Text(12)	Name of the second (optional) observer
Start	Datetime	Time on laptop clock when track recording started
End	Datetime	Time on laptop clock when track recording ended
Visibility	Integer(32bit)	Code for seeing distance in meters 1: >500 m 2: 250-500 m 3: <250 m
Weather	Integer(32bit)	Weather conditions 0: <50% Cloud cover 1: >50% Cloud cover 2: Fog 3: Mist – Light rain 4: Moderate – Heavy rain
Beaufort	Integer(32bit)	Beaufort Scale for Sea State 0: Calm <1 km/h; 0 cm, Glossy 1: Light air 1-3 km/h; 0-20 cm, Ripples 2: Light breeze 3-7 km/h; 20-50 cm, Few whitecaps 3: Gentle breeze 8-12 km/h; 50-100 cm, Scattered whitecaps 4: Moderate breeze 13-17 km/h; 1-2 m, Frequent whitecaps, spray
Protocol_ID	Text(50)	Name of the data collection protocol being observed
OnTransect	Text(5)	“True”: location is being recorded and observations can be made “False”: location is being recorded but observations are not being made.

F.5.3 GPSPoints Feature Class

Column	Data Type	Notes
ObjectID	Integer(32bit)	Managed by GIS; see note below
GlobalID	Guid	Managed by GIS; see note below
Shape	Blob	Managed by GIS; only editable with spatial tools
GpsPointID	Guid	Primary key, assigned by application, or when editing in ArcMap
TrackID	Guid	Foreign key to TrackID column in Tracks Feature Class
Lat_dd	Double	Latitude as reported in the NMEA sentence by the GPS device converted to decimal degrees if necessary
Long_dd	Double	Longitude as reported in the NMEA sentence by the GPS device converted to decimal degrees if necessary
Time_utc	Datetime	Universal date/time as reported in the NMEA sentence by the GPS device
Time_local	Datetime	Time_utc converted to local time using the Timezone information in the laptop
HDOP	Double	Horizontal degree of precision. A measure of the accuracy of the GPS coordinates as reported in the NMEA sentence by the GPS device
Satellite_Count	Integer(32bit)	Number of satellites used to fix the location (less than or equal to the number of visible satellites) as reported in the NMEA sentence by the GPS device
Speed	Double	Speed of the vessel in kilometers per hour as reported in the NMEA sentence by the GPS device
Bearing	Double	Bearing of the GPS in degrees azimuth north as reported in the NMEA sentence by the GPS device.
GPS_Fix_Status	Integer(32bit)	GPS Status as reported in the NMEA sentence by the GPS device 0: No fix on the location 1: Standard GPS fix 2: Differential GPS fix 3-8: possible values that are not used.

F.5.4 Observations Feature Class

Column	Data Type	Notes
ObjectID	Integer(32bit)	Managed by GIS; see note below
GlobalID	Guid	Managed by GIS; see note below
Shape	Blob	Managed by GIS; only editable with spatial tools
ObservationID	Guid	Primary key, assigned by application, or when editing in ArcMap
GpsPointID	Guid	Foreign key to GpsPointID column in GpsPoints Feature Class
Angle	Integer(32bit)	0 to 360 Angle in degrees from the observer to the bird. 0 and 360 are dead astern, 90 is port, 180 is dead ahead, 270 is starboard
Distance	Integer(32bit)	1 to 500 Distance in meters from the observer to the bird group.

F.5.5 BirdGroups Feature Class

Column	Data Type	Notes
ObjectID	Integer(32bit)	Managed by GIS; see note below
GlobalID	Guid	Managed by GIS; see note below
Shape	Blob	Managed by GIS; only editable with spatial tools
ObservationID	Guid	Foreign key to ObservationID column in Observations Feature Class
GroupSize	Integer(32bit)	Number of birds in this group 1 to 99
Behavior	Text(1)	“W”: Water (floating or diving) “F”: Flying
Species	Text(1)	“K”: Kittlitz’s murrelet “M”: marbled murrelet “U”: Unidentified, and that is final “P”: Unidentified, but hoping for positive identification
Comments	Text(255)	

Notes:

- 1) The ObjectID, and GlobalID fields are in all tables and are managed by GIS. They are not editable. They are volatile and therefore not suitable for use as a primary key. The ObjectID is used in map display, and the Global ID is used for syncing records between the file geodatabase and the mobile cache.
- 2) Double is a 64 bit real (floating point) value. The precision and scale are not documented, and it is assumed to be determined by the hardware.
- 3) Guid is a globally unique identifier
- 4) Datetime is an ESRI data type that stores the date and time in an undocumented format.

F.6 Miscellaneous

F.6.1 Contact Information

This application was developed by the NPS, Alaska Region GIS Team.

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F.6.2 Script Details

C:\KIMU\Scripts\1)InstallOrUpdateMachine.bat

This script needs to be run at least once per machine after ArcGIS mobile is installed. It should be run again if ArcGIS Mobile or NPTransect-KIMU is upgraded.

C:\KIMU\Scripts\2)InstallOrUpdateUser.bat

This script needs to be run at least once for each data recorder. It should be run again if

- Script 1 is run
- The background imagery is updated
- The database schema changes
- the layer properties in C:\KIMU\Murrelets (sync).mxd change

C:\KIMU\Scripts\3)SyncUser.bat

This script can be run as often as desired, but should always be run before running script 4.

C:\KIMU\Scripts\4)ExportToCSV.bat

This script can be run as often as desired, but daily is the minimum suggested. The results will only differ from the previous run if script 3 has been run first. Each run will overwrite the output from the previous run. Be sure that the CSV file is not open in Excel when this script is run, or it will fail.

C:\KIMU\Scripts\5)SnapshotToZip.bat

This script should run as often as desired. It is suggested that it be run each time script 4 is run. If the script is run more than once in a day, it will overwrite the previous output for that day. Please remember to close any ArcMap documents that may have the murrelet data open before running this script or it will generate errors because some files in the file geodatabase are locked by ArcMap.

F.6.3 Field Checklist

- GPS output is set to NMEA
- GPS output is set to WGS84
- Laptop time zone and daylight savings time are correct

F.6.4 Notes

- Record Track Log Page: After deleting an observation/birdgroup, it takes about 1 second for the map to redraw.
- Edit Observation Page: If any birdgroup is not valid when new observation is clicked, then any edits in that birdgroup will be lost.
- If you lose GPS connection (batteries run out, cable disconnect), then all data will be saved, and the application will return to the starting map page. You can then try an re-establish GPS connection and restart recording on the tracklog. The tracklog page will remember all previous settings.
- If the GPS loses signal, then the boat will not move, and will appear ghosted (mostly translucent). You can operate as normal, but the coordinates will be stale until the GPS gets a signal.

F.6.5 Cautions

- Do not change the schema of the database or the layer properties in Murrelet (sync).mxd while data collecting (i.e., in between syncs between the database and the mobile device). Doing so will cause the sync to fail and the data in the mobile cache will be lost. You will need to update the schema in the mobile cache (script2) before you can sync.
- Do not change the schema of the database without coordinating with the programmer. Most schema changes will require changes to the application code.
- Do not change visibilities of fields in Murrelet (sync).mxd. This constitutes a change to the mobile schema, and may cause the application or syncing to fail.
- Do not use the identify tool in the mobile application to delete items (the mobile application does not honor relationships and it will create orphaned data)
- Enter key in all pages goes to the next page, not next field.
- The application will not load multiple transects with the same name.
- Treat transects as immutable (i.e., do not change them). In particular, do not delete, move or rename existing transects once a track log has been recorded against it.

- Be very careful editing project data in ArcMap, and be sure to follow the guidelines in F.4 Editing in ArcMap.

F.6.6 Troubleshooting

- If GPS location is outside the extents of the map (Glacier Bay) then the display will be blank, and it will not be possible to use the application.
- Be sure to check the definition queries in Murrelets (sync).mxd and ensure that the correct year and transect panels are being selected for import/export
- Do not use joins in Murrelets (sync).mxd. If there is a join on a layer, then that layer will not export to the mobile cache, even if the joined fields are only used for filtering the data and are not visible (not intended to be exported to the mobile cache).

Appendix G: SQL Object Summary

Version 1.0

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
	November 2012	S. Hoekman, W. Johnson, B. Moynahan, C. Sergeant	Initial version		1.0

G.1 Database Organization

SEAN uses one monolithic Microsoft SQL Server 2008r2 database to hold selected data from all of the SEAN vital sign monitoring programs. Each vital sign stores its proprietary objects in a schema named for the vital sign. For Kittlitz’s murrelet monitoring, the schema name is KM. An additional schema, designated SEAN, holds data commonly used by all vital signs. In particular, tables in SEAN track all deliverable submissions, validation attempts, certifications, and installation to repositories.

The databases are not directly accessible to users. Instead, standard vital sign deliverable products are retrieved by researchers using the “production” and “integration” web sites. Another web site, denoted “data management” is used to update database content and also to generate intermediate products that are not, of themselves, deliverables. The data management web site is only available to specifically authorized staff.

Three versions of this database are maintained, serving three different purposes. Their content typically diverges among each other. The first database is named SEAN_STAGING_TEST_2008. It is used solely for application development and is only accessible by developers. The second is named SEAN_STAGING_2008. This contains the latest vital sign data. However, it may be incomplete for a particular period because not every certified product may yet be in place. SEAN_STAGING_2008 is typically accessed through its companion “integration web site” as well as the “data management web site.” The third database version, denoted SEAN, resides at NRSS in Colorado. It contains the most current complete data and may be thought of as SEAN_STAGING_2008 less any works in progress. Its content is accessed only through the “production web site”, which is also in Colorado. This last database/web site is the only one that external internet users may query. The organization is illustrated in Figure G.1.

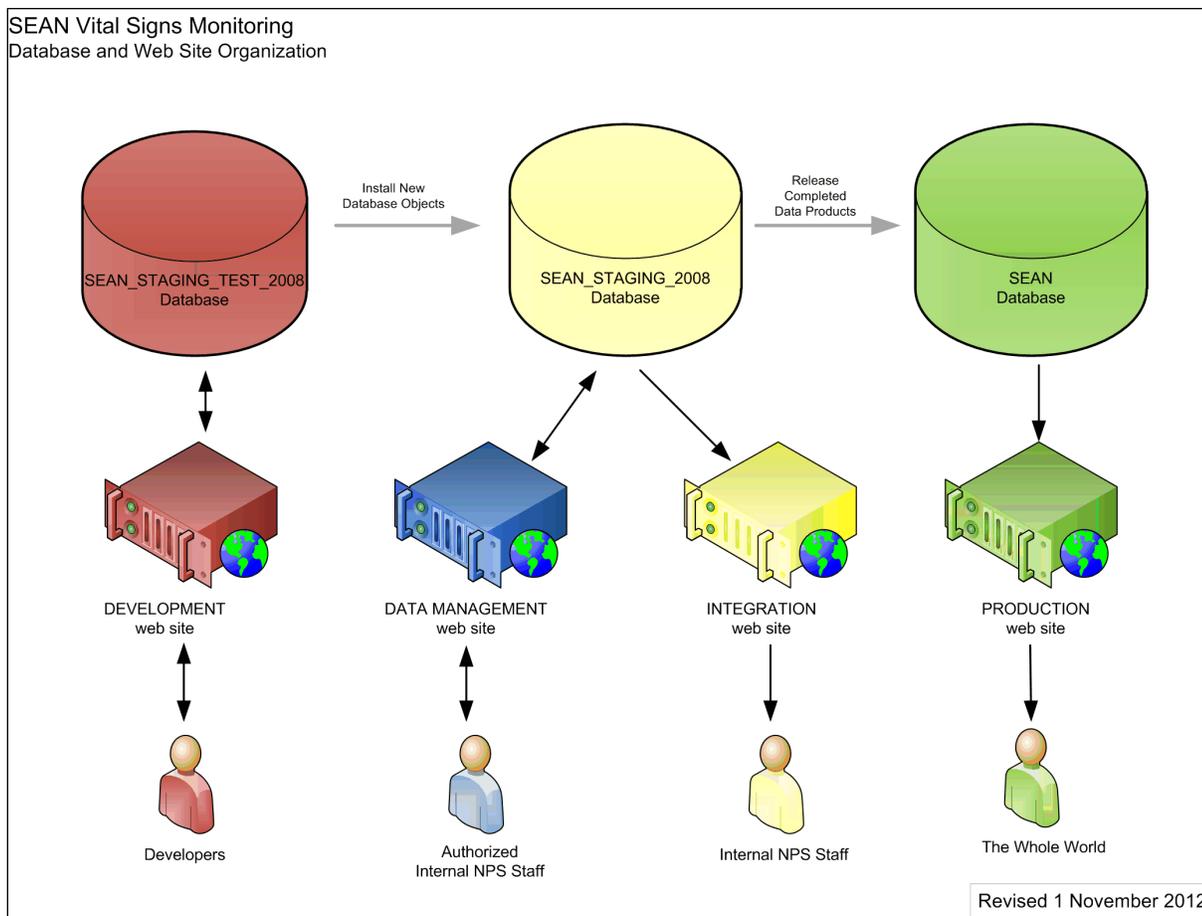


Figure G.1. SEAN database and web site organization.

G.2 Important objects in the KM schema

(The creation and consumption of the following objects are depicted in Figure G.2)

G.2.1 *Tbl_abundance_estimates*

The final KM_K product resides here. It contains estimates for each year of status and trend for the species designated Kittlitz's, marbled, unknown, and *Brachyramphus* (all murrelets). Estimates are provided for abundance, adjusted encounter rates, density, and encounter rates. Confidence limits and other statistics accompany the estimates. The content matches that of Table SOP 12.3 in protocol version KM-2012.1.

G.2.2 *Tbl_detection_centerline*

This one-row table contains static values for certain attributes that go into the DISTANCE output file (Table SOP12.2). The parameter "Probability of detection near transect center line P_c ", as well as its standard error and degrees of freedom are present in the row.

G.2.3 *Tbl_dfstats*

This contains the output of program DISTANCE (Table SOP 11.3). For each year it includes two sets of rows: one set for trend estimation and another set for status estimation. One parameter is also retrieved from *tbl_detection_centerline* instead of from program DISTANCE.

G.2.4 Tbl_km_observation

One row of data for each murrelet group observation made. The content is extracted from the KM_D Corrected Observations GIS file geodatabase.

G.2.5 Tbl_km_transect_scope

Details of each transect surveyed including actual length observed, midpoint coordinates, endpoint locations, and sampling inclusion probability. This comes from the GIS file geodatabase.

G.3 Data Flow through KM Database Objects

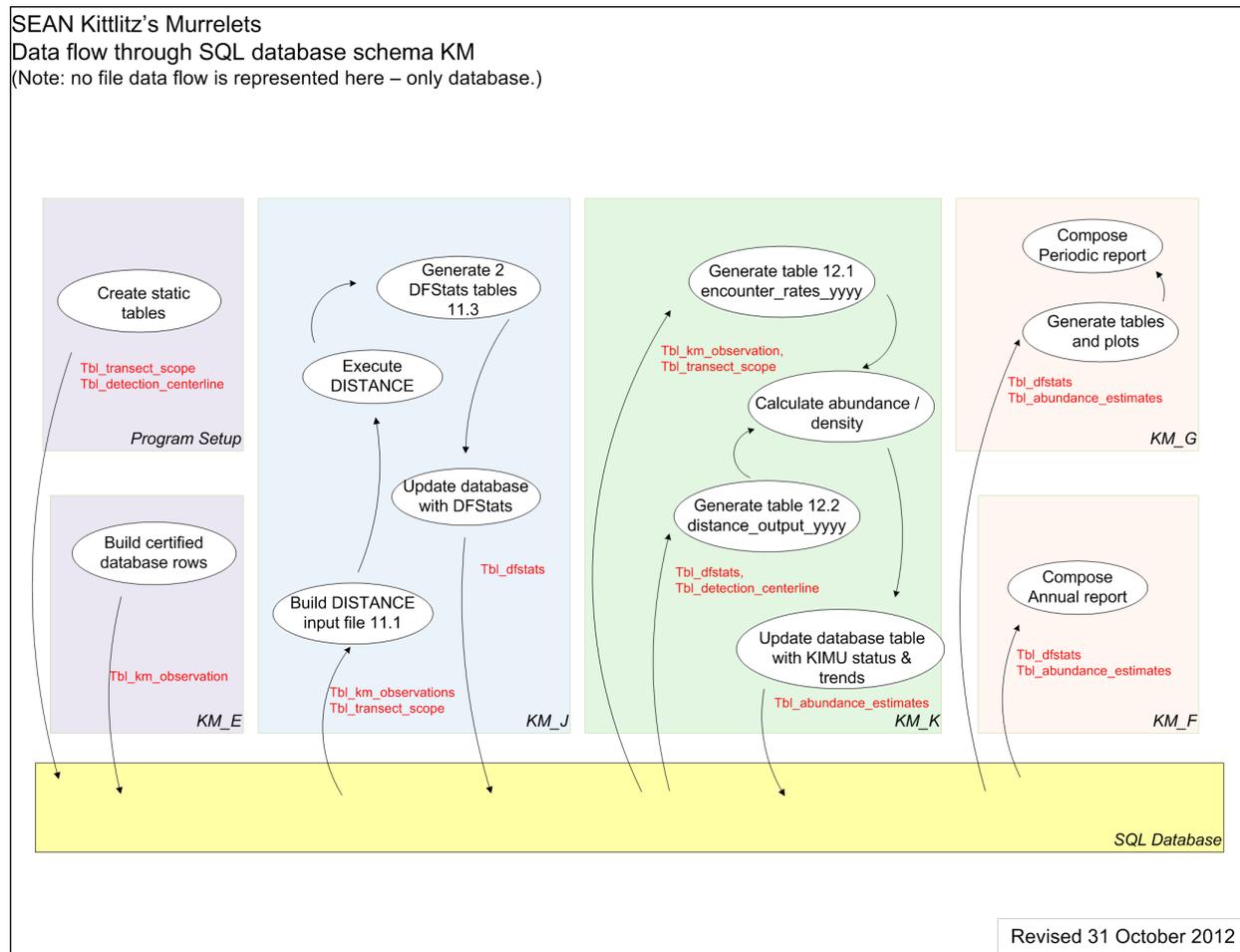


Figure G.2. Data flow through the KM SQL database objects.

G.4 Important Objects in the SEAN Schema

G.4.1 Tbl_deliverable

The deliverable designators from Table 4.1 of each monitoring protocol are documented here. Only items defined in this table may enter the validation stream; the submission tracking applications enforce this.

G.4.2 Tbl_protocol

The set of protocol designators ever used for each vital sign. All database rows containing vital sign data are mandatorily flagged with protocol designators, each of which must match an entry in this table. It is possible for a single vital sign data table to contain data from any number of different protocol versions. The designator, which corresponds to a particular protocol document package, informs the researcher of the exact processes used to create any particular row in the table.

G.4.3 Tbl_submission_log

Whenever a formal deliverable is submitted for validation, it is tagged with a submission number. Each row in tbl_submission_log tracks the status of a specific submission, including its underlying protocol, validity level, error counts, dates of status change, project leader, and so on. All submissions, including their data files, are retained for audit purposes and the submission log provides the information needed for a complete analysis of precisely how data deliverables reached their current state.

Appendix H: Detailed Deliverable Definitions

Version 1.0

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
	November 2012	S. Hoekman, W. Johnson, B. Moynahan, C. Sergeant	Initial version		1.0

Deliverables are the data and information products that are validated, certified, archived, and disseminated through the Southeast Alaska Network. “Scientific deliverables” are typically built by the Project Leader and submitted to the Data Manager. A few “technical deliverables”, which are basically created mechanically, are built by the Data Manager. Regardless of the source, every deliverable is formally validated by the Data Manager and certified by the originator before it is made available.

In order to carry out the validation processes, it is necessary to define in complete detail the content, nature, and domain of each deliverable. These complete definitions also support subsequent interpretation of the deliverables by removing ambiguity regarding attributes.

Appendix H defines every deliverable supported by the SEAN Kittlitz’s murrelet monitoring program. It follows policies set in the SEAN Data Management Plan (Johnson and Moynahan 2008: SOP 302 – Data Management Considerations in Protocol Development). Using that method, the top level description of a deliverable is explained using a single form named either A, B, C, or D. The specific form used for a particular deliverable depends on the nature of the deliverable’s contents. Deliverables of a tabular type are further defined with a form X, where the structure of the table is described. Each individual attribute (i.e., column, field) of a table is then defined in detail using a form Y. Using this set of six forms, all data and information involved in the SEAN Kittlitz’s murrelet program (and other SEAN monitoring programs) are consistently, precisely, and fully defined.

Each deliverable is also documented with a data flow diagram. These explain exactly where underlying data come from, what processes are applied to them, where they are stored, and who is responsible for managing each process.

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H.1 KM_A: Target Transects

Purpose of deliverable: A set of target line transects are defined for surveys to follow in each survey year. Some transects are permanent and are surveyed during each survey year. Another class of “rotating panel” transects are surveyed in a 3-year rotation. Actual courses followed can only approximate each transect, as it is not possible to keep a boat exactly positioned on the line for an entire survey, so these are considered targets.

Frequency produced: The definition of target transects is set at the commencement of the monitoring program and is not expected to change.

Prerequisites: None.

Data flow:

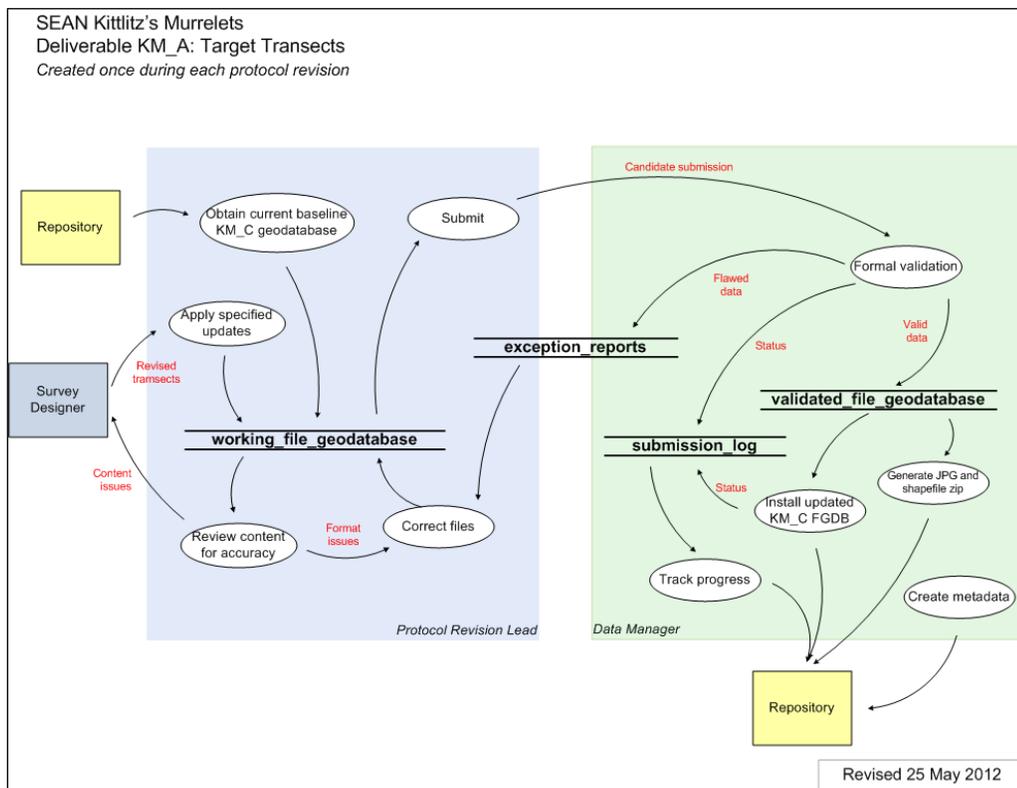


Figure H.1. Data flow required to generate deliverable KM_A - Target Transects.

Deliverable definition forms:

Form C: Non-Tabular Data Deliverable

<i>Vital Sign:</i> KM Kittlitz’s murrelets	<i>Deliverable ID:</i> KM_A part A	<i>Deliverable Title:</i> Target transects
<i>File format:</i> JPEG and ESRI shapefile as ZIP	<i>Associated software and version:</i> multiple	<i>Revision Date / protocol version:</i> 05-25-2012 / KM-2012.1
<i>Expected frequency:</i> Once	<i>Likely dissemination partners:</i> None – served by SEAN	<i>Submission unit:</i> None – only one deliverable
<i>What purpose does this deliverable serve?</i> Documents the survey routes.		
<i>Summary of content:</i> This file presents an overhead image of Glacier Bay proper in Alaska. On it are drawn a number of straight and/or zigzag lines delineating target survey transects. It is presented as a graphic in the JPEG format. Another version is made available as the file components of an ESRI shapefile, zipped into a single package.		
<i>Mandatory validation criteria:</i> JPG must be able to be opened by a web browser. Shapefile must be able to be opened by a version of ArcMap. Must present an image recognizable as a view of Glacier Bay, Alaska.		
<i>Optional validation criteria:</i> - None -		
<i>Deliverable ID of any other SEAN data products required to create this product:</i> Most recent KM_C raw observations file geodatabase, which contains ground-truthing tracklogs to base revisions on. A new version of KM_A has significant impact on data and analyses, so requires generating a new version of the KM_H protocol package.		
<i>Description and source of any outside data required to create this product:</i> The transects are defined by an expert in order to best meet the specific goals of the program, using special knowledge and tools.		

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Form D: Tabular Data Deliverable

<i>Vital Sign:</i> KM Kittlitz’s murrelets	<i>Deliverable ID:</i> KM_A part B	<i>Deliverable Title:</i> Target transects
<i>File format:</i> n/a	<i>Associated software and version:</i> n/a	<i>Revision Date / protocol version:</i> 12-18-2012 / 2012.1
<i>Expected frequency:</i> Once	<i>Likely dissemination partners:</i> None – served by SEAN	<i>Submission unit:</i> None – only one deliverable
<i>What purpose does this deliverable serve?</i> Defines characteristics of each transect, such as endpoints and panel number, as a downloadable table.		
<i>Identifiers of relations that compose the tabular deliverable (“Relations” are tables or files that provide information which may be represented in a grid format. Each relation listed must be fully defined in its own accompanying Form X.):</i> tbl_km_transect_scope		
<i>Deliverable ID of any other SEAN data products required to create this product:</i> KM_C raw observations file geodatabase, from which this deliverable was originally generated.		
<i>Description and source of any outside data required to create this product:</i> The transects are defined by an expert in order to best meet the specific goals of the program, using special knowledge and tools.		

Form X: Relation Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Relation identifier:</i> tbl_km_transect_scope	<i>Used by deliverable ID:</i> KM_A part B
<i>Revision date / protocol version:</i> 10-1-2012 / 2012.1	<i>Type of relation:</i> Database Table	<i>Estimated rows:</i> 180
<i>Primary key for this relation:</i> Transect_id		
<i>Purpose:</i> The transect scope table was copied from the file geodatabase at monitoring program inception. It contains each transect's full length, endpoints, midpoints, and other transect-specific information. This information is typically static and does not change from year to year. It is created through ArcGIS manipulation and is not subject to automated validation. The table is not expected to be updated except when a significant revision to the sampling methodology is made.		
<i>Identifiers of attributes defined over this relation ("Attributes" are columns of the grid. Each attribute must be defined in an accompanying Form Y.):</i>		
TRANSECT_ID	PANEL	
SCOPE_LENGTH	SCOPE_LATITUDE_MIDPOINT	
SCOPE_LONGITUDE_MIDPOINT	TREND_COMPONENT	
STATUS_COMPONENT	INCLUSION_PROBABILITY	
BOAT_PATH_LENGTH	LATITUDE_START	
LONGITUDE_START	LATITUDE_STOP	
LONGITUDE_STOP	USERID	
TIME_STAMP	PROTOCOL_ID	
<i>Mandatory validation criteria involving multiple attributes:</i> - none -		
<i>Optional validation criteria involving multiple attributes:</i> - none -		

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> TRANSECT_ID	<i>Used by deliverable ID:</i> KM_A part B
<i>Revision date / protocol version:</i> 10-1-2012 / 2012.1	<i>Default report heading:</i> Transect Name	<i>Relation (from Form X):</i> tbl_km_transect_scope
<i>Purpose:</i> Identifier used to designate a particular transect on which data are collected.		
<i>Data type:</i>	Varchar(24)	
<i>Maximum length</i>	24	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	Ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> PANEL	<i>Used by deliverable ID:</i> KM_A part B
<i>Revision date / protocol version:</i> 10-1-2012 / 2012.1	<i>Default report heading:</i> Panel	<i>Relation (from Form X):</i> tbl_km_transect_scope
<i>Purpose:</i> The panel membership of each transect. Available panels are denoted "0" through "4". Panel 0 is sampled every year. Panel 1 is sampled every third year beginning in 2010, Panel 2 is sampled every third year beginning in 2011. Panel 3 is sampled every third year beginning in 2012. Panel 4 contains alternate transects available for use in the event a transect from another panel becomes permanently unusable.		
<i>Data type:</i>	Varchar	
<i>Maximum length</i>	1	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> SCOPE_LENGTH	<i>Used by deliverable ID:</i> KM_A part B
<i>Revision date / protocol version:</i> 10-1-2012 / 2012.1	<i>Default report heading:</i> Transect Scope Length	<i>Relation (from Form X):</i> tbl_km_transect_scope
<i>Purpose:</i> The distance along a transect which observers confine their observations to. This contrasts with BOAT_PATH_LENGTH, which is always shorter because boats cannot be driven up to the shoreline (while observers can see up to the shoreline). SCOPE_LENGTH is determined by taking the boat length and then adding the two distances to the physical endpoints of observation, typically the land margin. On endpoints where the defined boat path stops more than 150m from land, the scope is considered to terminate at 150m and only observations within that distance are recorded.		
<i>Data type:</i>	Real	
<i>Maximum length</i>	16	
<i>Required:</i>	no	
<i>Measurement units:</i>	km	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> SCOPE_LATITUDE_MIDPOINT	<i>Used by deliverable ID:</i> KM_A part B
<i>Revision date / protocol version:</i> 10-1-2012 / 2012.1	<i>Default report heading:</i> Midpoint Latitude	<i>Relation (from Form X):</i> tbl_km_transect_scope
<i>Purpose:</i> The WGS84 latitude in decimal degrees of the place along the polyline equidistant from the endpoints of the observed transect.		
<i>Data type:</i>	Real	
<i>Maximum length</i>	16	
<i>Required:</i>	no	
<i>Measurement units:</i>	Decimal degrees	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> SCOPE_LONGITUDE_MIDPOINT	<i>Used by deliverable ID:</i> KM_A part B
<i>Revision date / protocol version:</i> 10-1-2012 / 2012.1	<i>Default report heading:</i> Midpoint Longitude	<i>Relation (from Form X):</i> tbl_km_transect_scope
<i>Purpose:</i> The WGS84 longitude in decimal degrees of the place along the polyline equidistant from the endpoints of the observed transect.		
<i>Data type:</i>	Real	
<i>Maximum length</i>	16	
<i>Required:</i>	no	
<i>Measurement units:</i>	Decimal degrees	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> TREND_COMPONENT	<i>Used by deliverable ID:</i> KM_A part B
<i>Revision date / protocol version:</i> 10-1-2012 / 2012.1	<i>Default report heading:</i> Trend	<i>Relation (from Form X):</i> tbl_km_transect_scope
<i>Purpose:</i> A flag indicating whether to include this transect in analyses of population trend. A value of "Y" indicates it is to be used.		
<i>Data type:</i>	Varchar	
<i>Maximum length</i>	1	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> STATUS_COMPONENT	<i>Used by deliverable ID:</i> KM_A part B
<i>Revision date / protocol version:</i> 10-1-2012 / 2012.1	<i>Default report heading:</i> Status	<i>Relation (from Form X):</i> tbl_km_transect_scope
<i>Purpose:</i> A flag indicating whether to include this transect in analyses of population status. A value of "Y" indicates it is to be used.		
<i>Data type:</i>	Varchar	
<i>Maximum length</i>	1	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> INCLUSION_PROBABILITY	<i>Used by deliverable ID:</i> KM_A part B
<i>Revision date / protocol version:</i> 10-1-2012 / 2012.1	<i>Default report heading:</i> Inclusion probability	<i>Relation (from Form X):</i> tbl_km_transect_scope
<i>Purpose:</i> Inclusion probability (probability of selection for sampling) for each transect; derived from the sampling design and fixed at program inception.		
<i>Data type:</i>	Real	
<i>Maximum length</i>	16	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> BOAT_PATH_LENGTH	<i>Used by deliverable ID:</i> KM_A part B
<i>Revision date / protocol version:</i> 10-1-2012 / 2012.1	<i>Default report heading:</i> Target Boat Path Length	<i>Relation (from Form X):</i> tbl_km_transect_scope
<i>Purpose:</i> The distance the boat is expected to travel on a transect. This is always less than the TRANSECT_SCOPE.		
<i>Data type:</i>	Real	
<i>Maximum length</i>	16	
<i>Required:</i>	no	
<i>Measurement units:</i>	km	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> LATITUDE_START	<i>Used by deliverable ID:</i> KM_A part B
<i>Revision date / protocol version:</i> 10-1-2012 / 2012.1	<i>Default report heading:</i> Target Boat Start Latitude	<i>Relation (from Form X):</i> tbl_km_transect_scope
<i>Purpose:</i> The WGS84 latitude in decimal degrees of the location the boat should be located at the start of a transect.		
<i>Data type:</i>	Real	
<i>Maximum length</i>	16	
<i>Required:</i>	no	
<i>Measurement units:</i>	Decimal degrees	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> LONGITUDE_START	<i>Used by deliverable ID:</i> KM_A part B
<i>Revision date / protocol version:</i> 10-1-2012 / 2012.1	<i>Default report heading:</i> Target Boat Start Longitude	<i>Relation (from Form X):</i> tbl_km_transect_scope
<i>Purpose:</i> The WGS84 longitude in decimal degrees of the location the boat should be located at the start of a transect.		
<i>Data type:</i>	Real	
<i>Maximum length</i>	16	
<i>Required:</i>	no	
<i>Measurement units:</i>	Decimal degrees	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> LATITUDE_STOP	<i>Used by deliverable ID:</i> KM_A part B
<i>Revision date / protocol version:</i> 10-1-2012 / 2012.1	<i>Default report heading:</i> Target Boat Stop Latitude	<i>Relation (from Form X):</i> tbl_km_transect_scope
<i>Purpose:</i> The WGS84 latitude in decimal degrees of the location the boat should be located at the completion of a transect.		
<i>Data type:</i>	Real	
<i>Maximum length</i>	16	
<i>Required:</i>	no	
<i>Measurement units:</i>	Decimal degrees	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> LONGITUDE_STOP	<i>Used by deliverable ID:</i> KM_A part B
<i>Revision date / protocol version:</i> 10-1-2012 / 2012.1	<i>Default report heading:</i> Target Boat Stop Longitude	<i>Relation (from Form X):</i> tbl_km_transect_scope
<i>Purpose:</i> The WGS84 longitude in decimal degrees of the location the boat should be located at the completion of a transect.		
<i>Data type:</i>	Real	
<i>Maximum length</i>	16	
<i>Required:</i>	no	
<i>Measurement units:</i>	Decimal degrees	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> TIME_STAMP	<i>Used by deliverable ID:</i> KM_A part B
<i>Revision date / protocol version:</i> 10-1-2012 / 2012.1	<i>Default report heading:</i> Last Updated	<i>Relation (from Form X):</i> tbl_km_transect_scope
<i>Purpose:</i> The date and time this row was most recently inserted or updated in the table. It is used for auditing purposes.		
<i>Data type:</i>	datetime	
<i>Maximum length</i>	n/a	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> USERID	<i>Used by deliverable ID:</i> KM_A part B
<i>Revision date / protocol version:</i> 10-1-2012 / 2012.1	<i>Default report heading:</i> Updated by	<i>Relation (from Form X):</i> tbl_km_transect_scope
<i>Purpose:</i> The login name used to authorize the process that created/updated this row in the cumulative database. It is used for auditing purposes.		
<i>Data type:</i>	Varchar(20)	
<i>Maximum length</i>	20	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> PROTOCOL_ID	<i>Used by deliverable ID:</i> KM_A part B
<i>Revision date / protocol version:</i> 10-1-2012 / 2012.1	<i>Default report heading:</i> Protocol	<i>Relation (from Form X):</i> tbl_km_transect_scope
<i>Purpose:</i> The formal version identifier of the monitoring protocol document that was observed during the creation of these data. For example, "KM-2012.1".		
<i>Data type:</i>	Varchar(10)	
<i>Maximum length</i>	20	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	sean.protocol.protocol	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must match an entry in tbl_protocol.	
<i>Optional validation rules for this attribute:</i>	- none -	

H.2 KM_B: Field Data Observer Form Images

Purpose of deliverable: These are scanned images of the original sampling log sheets used to record the exceptional information for each transect surveyed. They are collected to support after-the-fact correction of errors in KM_C raw observations. Notes on the images may also be viewed to explain any exceptional events that occurred on each transect. Both front and back of each form are recorded, unless completely blank.

Frequency produced: These are created annually, after completion of the field season.

Prerequisites: Availability of the complete set of paper observer forms for the survey year.

Data flow:

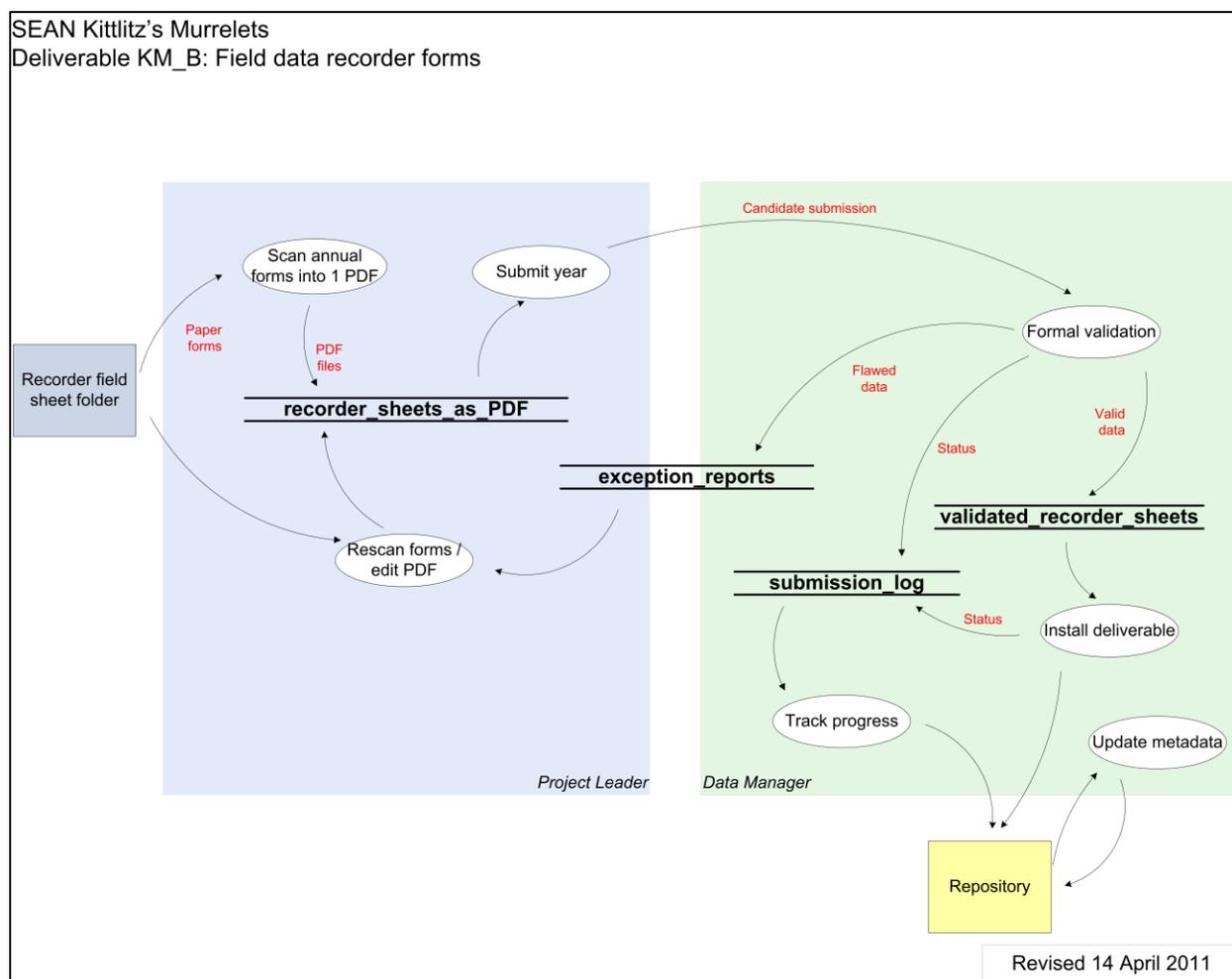


Figure H.2. Data flow required to generate deliverable KM_B – Field Data Observer Form Images.

Deliverable definition forms:

Form C: Non-Tabular Data Deliverable

<i>Vital Sign:</i> KM Kittlitz’s murrelets	<i>Deliverable ID:</i> KM_B	<i>Deliverable Title:</i> Field data observer form images
<i>File format:</i> PDF	<i>Associated software and version:</i> Adobe Reader 11	<i>Revision Date / protocol version:</i> 11-05-2012/ KM-2012.1
<i>Expected frequency:</i> 1/year	<i>Likely dissemination partners:</i> None – served by SEAN	<i>Submission unit:</i> Year
<i>What purpose does this deliverable serve?</i> Source documents used for researching data errors and individual exceptions.		
<i>Summary of content:</i> Scanned images of field observer sheets.		
<i>Mandatory validation criteria:</i> <ol style="list-style-type: none"> 1. Must successfully open using Adobe Reader 11.0 or greater. 2. Filename must conform to submission unit pattern described in SOP detailed steps. 3. Dates on form images must be in range of submission unit. 		
<i>Optional validation criteria:</i> <ol style="list-style-type: none"> 1. Should reflect all transects for the year with no gaps. 		
<i>Deliverable ID of any other SEAN data products required to create this product</i> - none -		
<i>Description and source of any outside data required to create this product:</i> Paper log sheets from field crews.		

H.3 KM_C: Raw Observations

Purpose of deliverable: Raw observations of murrelet sightings along with tracklogs of actual paths taken over the duration of each particular transect. Values from this provide the basis for abundance and density estimates each year.

Frequency produced: KM_C is created at the end of each season by copying the entire data collection package from field laptop folder C:\KIMU to the network and zipping it into a single file.

Prerequisites: None.

Data flow:

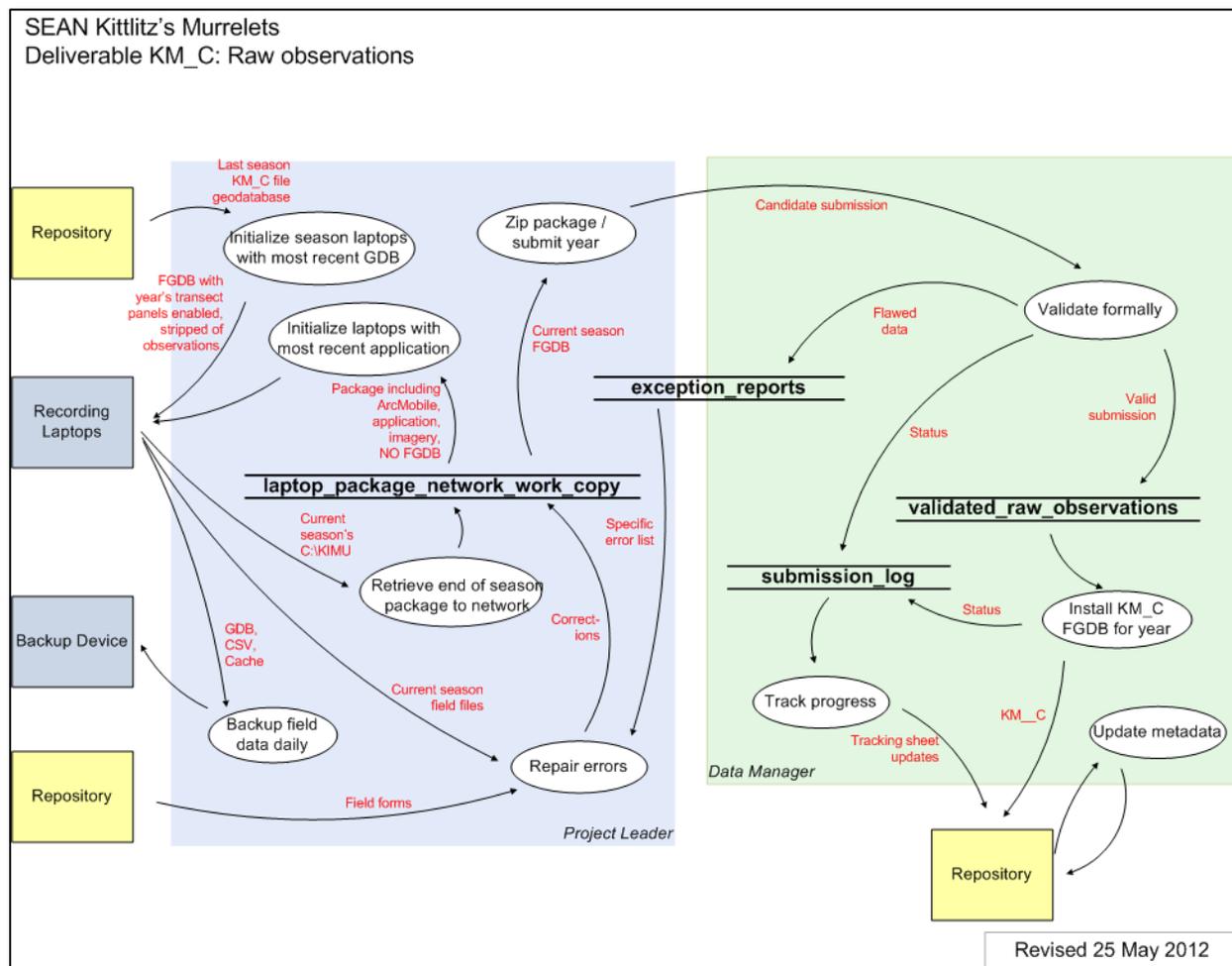


Figure H.3. Data flow required to generate deliverable KM_C – Raw Observations.

Deliverable definition forms:

Form C: Non-Tabular Data Deliverable

<i>Vital Sign:</i> KM Kittlitz’s murrelets	<i>Deliverable ID:</i> KM_C	<i>Deliverable Title:</i> Raw observations
<i>File format:</i> ZIP of ESRI File Geodatabase	<i>Associated software and version:</i> WINZIP, etc. ArcGIS 10.0	<i>Revision Date / protocol version:</i> 05-25-2012/ KM-2012.1
<i>Expected frequency:</i> 1/year	<i>Likely dissemination partners:</i> None – served by SEAN	<i>Submission unit:</i> Year
<i>What purpose does this deliverable serve?</i> 1. Provides a GIS-based record of all monitoring survey activity for a particular calendar year.		
<i>Summary of content:</i> 1. ESRI file geodatabase containing all transect locations, raw observations and tracklogs recorded by the Kittlitz’s murrelet monitoring program for a particular year, in a zipped package.		
<i>Mandatory validation criteria:</i> 1. Filename must conform to the pattern for the submission unit as described in the SOP 3 detailed steps. 2. Folder structure must successfully open using WinZip version 11.0 or similar software. 3. When the candidate KM_C is unzipped there must be a single root folder named Murrelets.gdb Within that folder a number of files must be present, though their names and specific content are not significant to validation. 4. The following features must be accessible using ArcMap 10.0 or greater once linked to the unzipped Murrelets.gdb file geodatabase: Bird Groups, GPS Points, Observations, Tracks, and Transects. None of these features may be empty of content.		
<i>Optional validation criteria:</i> - none -		
<i>Deliverable ID of any other SEAN data products required to create this product</i> The NPTransect system’s fully defined geodatabase having a scope of only the current year.		
<i>Description and source of any outside data required to create this product:</i> - none –		

H.4 KM_D: Corrected Observations

Purpose of deliverable: After the certified field observation geodatabase folder for the year (KC_C) is retrieved from the web site, corrections are applied to it. Corrections typically include items noted on field data observer forms, which may include up to whole new observations being added in the event electronic field capture failed. A CSV file is generated off the corrected geodatabase. Gross data quality flags are then edited into the CSV. The new geodatabase folder and CSV file are zipped into a file, which is the KM_D deliverable.

Frequency produced: KM_D is created at the end of each season after the underlying KM_C raw observations have been certified.

Prerequisites: KM_B field data observer forms. KM_C raw observations. KM_I waypoints.

Data flow:

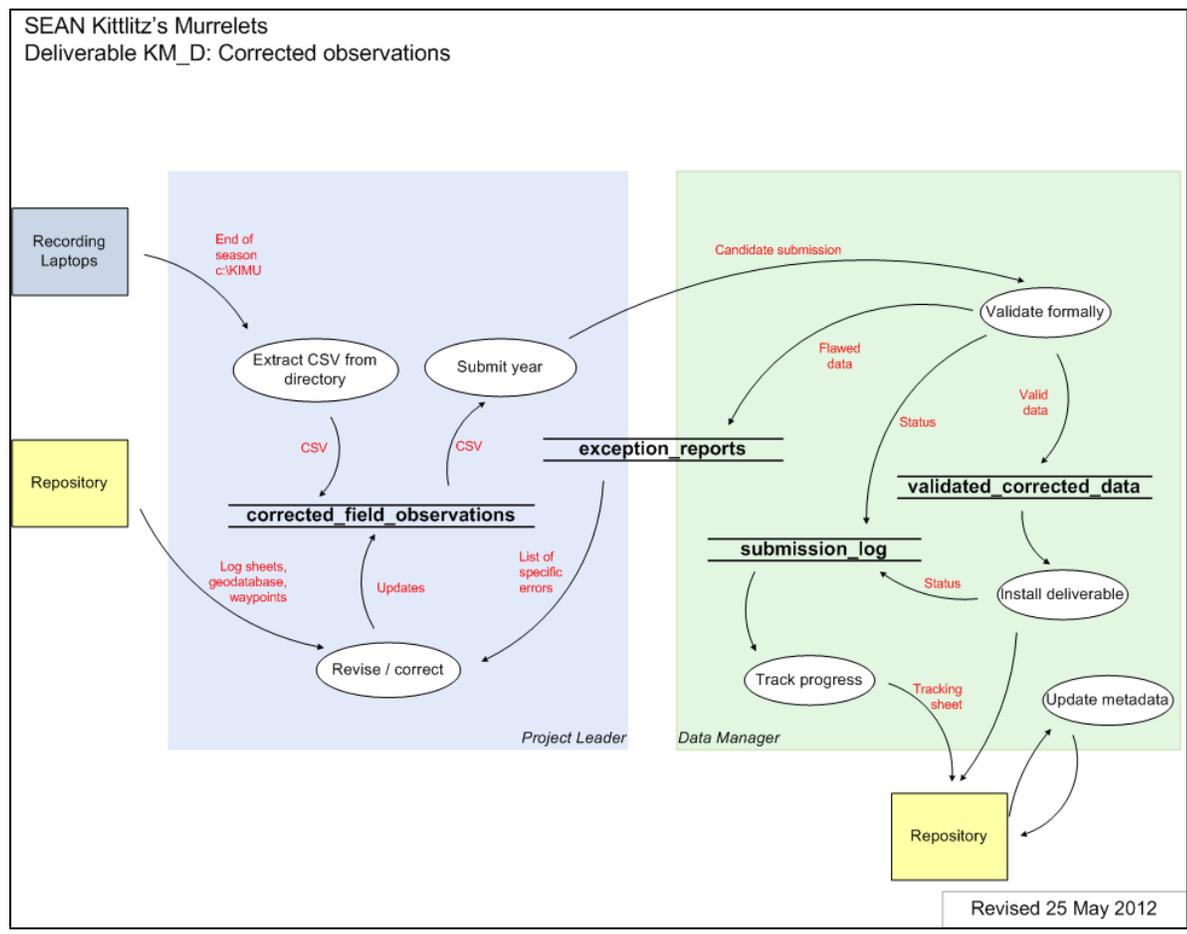


Figure H.4. Data flow required to generate deliverable KM_D – Corrected Observations.

Deliverable definition forms:

Form D: Tabular Data Deliverable

<i>Vital Sign:</i> KM Kittlitz’s murrelets	<i>Deliverable ID:</i> KM_D	<i>Deliverable Title:</i> Corrected observations
<i>File format:</i> ZIP	<i>Associated software and version:</i> PKZIP, R, Excel, ArcGIS.	<i>Revision Date / protocol version:</i> 09-30-2012 / 2012.1
<i>Expected frequency:</i> 1 ZIP file/year	<i>Likely dissemination partners:</i> None – served by SEAN	<i>Submission unit:</i> YEAR
<p><i>What purpose does this deliverable serve?</i> Provides a year’s individual observation file containing all transects. The baseline KM_C geodatabase is corrected to the greatest degree possible. A CSV of tracklogs with observations is generated for the geodatabase. The CSV is edited to include indications of data quality. The corrected geodatabase and CSV are zipped into a package for dissemination together.</p> <p>The geodatabase portion of the ZIP package must have already been of the correct form in order for the CSV to be generated from it. Therefore, the geodatabase part of the deliverable does not have separate validation defined on it.</p>		
<p><i>Identifiers of relations that compose the tabular deliverable (“Relations” are tables or files that provide information which may be represented in a grid format. Each relation listed must be fully defined in its own accompanying Form X.):</i> KM_D_yyyy.CSV, where yyyy is 4-digit year of survey.</p>		
<p><i>Deliverable ID of any other SEAN data products required to create this product:</i> KM_B, KM_C, KM_I for corresponding year.</p>		
<p><i>Description and source of any outside data required to create this product:</i> - none -</p>		

Form X: Relation Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Relation identifier:</i> KM_D_yyyy.CSV	<i>Used by deliverable ID:</i> KM_D	
<i>Revision date / protocol version:</i> 09-30-2012 / 2012.1	<i>Type of relation:</i> <input type="radio"/> Database table <input type="radio"/> Data file	<i>Estimated rows:</i> 50,000/year	
<i>Primary key for this relation:</i> DATE_LOCAL TIME_LOCAL			
<i>Purpose:</i> Comma separated values for observations from murrelet surveys commingled with tracklogs for one transect in one year, including post-acquisition data quality assessment.			
<i>Identifiers of attributes defined over this relation ("Attributes" are columns of the grid. Each attribute must be defined in an accompanying Form Y.):</i> The first line of each file consists only of the special attribute <table border="1" style="width: 100%;"> <tr> <td>HEADER</td> </tr> </table>			HEADER
HEADER			
The remaining lines contain these attributes:			
TRANSECT_ID	DATE_LOCAL		
TIME_LOCAL	VESSEL		
RECORDER	OBSERVER_1		
OBSERVER_2	BEAUFORT		
WEATHER_CODE	VISIBILITY		
LATITUDE_WGS84	LONGITUDE_WGS84		
UTM8_EASTING	UTM8_NORTHING		
SPEED	BEARING		
ANGLE	DISTANCE		
BEHAVIOR	GROUP_SIZE		
SPECIES	ON_TRANSECT		
PROTOCOL_ID	GPS_STATUS		
SATELLITES	HDOP		
TRACK_LENGTH	COMMENTS		
DATA_QUALITY	DATA_QUALITY_COMMENT		
<i>Mandatory validation criteria involving multiple attributes:</i> - none -			
<i>Optional validation criteria involving multiple attributes:</i> If DATA_QUALITY > 0, DATA_QUALITY_COMMENT should not be null. If DATA_QUALITY_COMMENT is present, DATA_QUALITY should not be null. If ON_TRANSECT is not TRUE, then there should be no values for ANGLE, DISTANCE, BEHAVIOR, GROUP_SIZE, SPECIES.			

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> HEADER	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> - None -	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> Heading containing fixed keywords used to designate content of columns in remainder of file.		
<i>Data type:</i>	Varchar(500)	
<i>Maximum length</i>	500	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	Unformatted string	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	Ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must contain all of the following substrings: TRANSECT_ID, DATE_LOCAL, TIME_LOCAL, VESSEL, RECORDER, OBSERVER_1, OBSERVER_2, BEAUFORT, WEATHER_CODE, VISIBILITY, LATITUDE_WGS84, LONGITUDE_WGS84, UTM8_EASTING, UTM8_NORTHING, SPEED, BEARING, ANGLE, DISTANCE, BEHAVIOR, GROUP_SIZE, SPECIES, ON_TRANSECT, PROTOCOL_ID, GPS_STATUS, SATELLITES, HDOP, TRACK_LENGTH, COMMENTS, DATA_QUALITY, DATA_QUALITY_COMMENT 	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> TRANSECT_ID	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Transect	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> Identifier used to designate a particular transect on which data were collected. The specific transect IDs employed in a survey are not constant from year to year.		
<i>Data type:</i>	Varchar(24)	
<i>Maximum length</i>	24	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	Ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	none	
<i>Optional validation rules for this attribute:</i>	none	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> DATE_LOCAL	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Date	<i>Relation (from Form X):</i> KM_D_yyyy CSV
<i>Purpose:</i> Date the trackpoint or observation was taken; in the local ADT time zone.		
<i>Data type:</i>	Varchar(12)	
<i>Maximum length</i>	12	
<i>Required:</i>	yes	
<i>Measurement units:</i>	Date	
<i>Format:</i>	yyyy-mm-dd	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must represent a valid a date. 2. Must not be a date beyond the current one at point of validation. 3. Must not be a date before 2009. 	
<i>Optional validation rules for this attribute:</i>	<ol style="list-style-type: none"> 1. Month part of date should be between May and August 	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> TIME_LOCAL	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Time	<i>Relation (from Form X):</i> KM_D_yyyy CSV
<i>Purpose:</i> Time the trackpoint or observation was taken; in the local ADT time zone and expressed using a 24-hour clock.		
<i>Data type:</i>	Varchar(8)	
<i>Maximum length</i>	8	
<i>Required:</i>	yes	
<i>Measurement units:</i>	Time	
<i>Format:</i>	hh:mm:ss	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must represent a valid a time.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> VESSEL	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-04-2011 / 2012.1	<i>Default report heading:</i> Vessel	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> The name of the boat used to survey this transect.		
<i>Data type:</i>	Varchar(24)	
<i>Maximum length</i>	24	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	Ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> RECORDER	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-04-2011 / 2012.1	<i>Default report heading:</i> Recorder	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> The name of the person who operated the data recording station (Data Recorder) on this transect, typically as initials.		
<i>Data type:</i>	Varchar(24)	
<i>Maximum length</i>	24	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	Ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> OBSERVER_1	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-04-2011 / 2012.1	<i>Default report heading:</i> First observer	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> The name of the first survey Observer on this transect (typically as initials). OBSERVER_1 is used when a single person conducts the survey. OBSERVER_1 denotes the left (port) side Observer when two are used.		
<i>Data type:</i>	Varchar(24)	
<i>Maximum length</i>	24	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	Ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> OBSERVER_2	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-04-2011 / 2012.1	<i>Default report heading:</i> Second observer	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> The name of the second survey Observer (typically as initials), on the right (starboard) side of the vessel. Used only when surveys are conducted by two Observers.		
<i>Data type:</i>	Varchar(24)	
<i>Maximum length</i>	24	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	Ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> BEAUFORT	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Beaufort sea state	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> Estimate of sea state encountered on a transect using the Beaufort scale: 0 – Calm / Flat. 1 – Light air / Scaly ripples, no foam crests. 2 – Light breeze / Small wavelets. Crests of glassy appearance, not breaking. 3 – Gentle breeze / Large wavelets. Crests begin to break; scattered whitecaps.		
<i>Data type:</i>	Varchar(1)	
<i>Maximum length</i>	1	
<i>Required:</i>	no	
<i>Measurement units:</i>	Beaufort scale designators	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present, must be one of '0', '1', '2', or '3'.	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> WEATHER_CODE	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Weather conditions	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> Observed weather using the following encoding: 0 – Less than 50% cloud cover. 1 – Greater than 50% cloud cover. 2 – Fog. 3 – Mist. 4 – Rain.		
<i>Data type:</i>	Varchar(1)	
<i>Maximum length</i>	1	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present, must be one of '0', '1', '2', '3', or '4'.	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> VISIBILITY	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Weather conditions	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> Visibility using the following encoding: 1 – Greater than 500 meters. 2 – Between 250 and 500 meters. 3 – Less than 250 meters.		
<i>Data type:</i>	Varchar(1)	
<i>Maximum length</i>	1	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present, must be one of '1', '2', or '3'.	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> LATITUDE_WGS84	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Latitude	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> Latitude of vessel in decimal degrees using the WGS84 datum.		
<i>Data type:</i>	Varchar(11)	
<i>Maximum length</i>	11	
<i>Required:</i>	yes	
<i>Measurement units:</i>	Decimal degrees	
<i>Format:</i>	99.99999999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must represent a valid real number. 2. Must be between 58.0 and 60.0. 	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> LONGITUDE_WGS84	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Longitude	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> Longitude of vessel in decimal degrees using the WGS84 datum.		
<i>Data type:</i>	Varchar(13)	
<i>Maximum length</i>	13	
<i>Required:</i>	yes	
<i>Measurement units:</i>	Decimal degrees	
<i>Format:</i>	-999.99999999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must represent a valid real number. 2. Must be between -135.0 and -138.0. 	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> UTM8_EASTING	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Easting	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> Longitude of vessel as expressed in meters using the Universal Transverse Mercator coordinate system for zone 8N and NAD83 datum.		
<i>Data type:</i>	Varchar(11)	
<i>Maximum length</i>	11	
<i>Required:</i>	no	
<i>Measurement units:</i>	Meters	
<i>Format:</i>	999999.9999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must represent a valid real number.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> UTM8_NORTHING	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Northing	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> Latitude of vessel as expressed in meters using the Universal Transverse Mercator coordinate system for zone 8N and NAD83 datum.		
<i>Data type:</i>	Varchar(12)	
<i>Maximum length</i>	12	
<i>Required:</i>	no	
<i>Measurement units:</i>	Meters	
<i>Format:</i>	9999999.9999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must represent a valid real number.	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> SPEED	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Boat speed	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> The momentary speed of the vessel in kilometers/hour as calculated by the GPS unit.		
<i>Data type:</i>	Varchar(10)	
<i>Maximum length</i>	10	
<i>Required:</i>	no	
<i>Measurement units:</i>	Km/h	
<i>Format:</i>	99.9999999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present, must represent a valid real number.	
<i>Optional validation rules for this attribute:</i>	1. When ON_TRANSECT is TRUE, SPEED should be between 0.0 and 20.0	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> BEARING	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Bearing	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> Bearing of boat in degrees as calculated by the GPS unit, with true north being 0 degrees.		
<i>Data type:</i>	Varchar(12)	
<i>Maximum length</i>	12	
<i>Required:</i>	no	
<i>Measurement units:</i>	Degrees	
<i>Format:</i>	999.99999999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present, must be between 0.0 and 359.99999999.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> ANGLE	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Angle	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> Angle of observed group from the survey Observer relative to a line running through the center of the boat from bow to stern with port being 90, forward 180, starboard 270, and aft 0 degrees.		
<i>Data type:</i>	Varchar(3)	
<i>Maximum length</i>	3	
<i>Required:</i>	no	
<i>Measurement units:</i>	Degrees	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must represent an integer between 1 and 359.	
<i>Optional validation rules for this attribute:</i>	1. Should be between 70 and 290. 2. Should be a multiple of 5 when less than 170 or greater than 190.	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> DISTANCE	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Distance	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> Estimated distance in meters from the survey Observer to center of observed murrelet group.		
<i>Data type:</i>	Varchar(3)	
<i>Maximum length</i>	3	
<i>Required:</i>	no	
<i>Measurement units:</i>	Meters	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must represent an integer between 1 and 500.	
<i>Optional validation rules for this attribute:</i>	1. Should be between 10 and 300. 2. Should be a multiple of 10.	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> BEHAVIOR	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Behavior	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> Indicator of whether the observed group is flying or on the water. A group may consist of only one species with one behavior. While recorded in initial survey years, the value is limited to 'W' in current practice.		
<i>Data type:</i>	Varchar(1)	
<i>Maximum length</i>	1	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present, must be 'F' or 'W'.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> GROUP_SIZE	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Group Size	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> Number of individuals (of one species) in the observed group.		
<i>Data type:</i>	Varchar(2)	
<i>Maximum length</i>	2	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must represent an integer between 1 and 99.	
<i>Optional validation rules for this attribute:</i>	1. Should be between 1 and 24.	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> SPECIES	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Species	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> Indicator of species for this group observed. A group may consist of only one species. K - Kittlitz's murrelet M – Marbled murrelet U – Unknown		
<i>Data type:</i>	Varchar(1)	
<i>Maximum length</i>	1	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present must be 'K', 'M', or 'U'.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> ON_TRANSECT	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> On Transect	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> Set to "True" if the current record was taken while following the designated transect for the survey. Set "False" if off transect, as at initial approach or when avoiding a hazard. This is required in order to support calculating the exact track length covered for a transect.		
<i>Data type:</i>	Varchar(5)	
<i>Maximum length</i>	5	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must be 'False' or 'True'.	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> PROTOCOL_ID	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Protocol	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> The formal version identifier of the monitoring protocol document that was observed during the collection of these data. For example, "KM-2012.1".		
<i>Data type:</i>	Varchar(10)	
<i>Maximum length</i>	10	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. This attribute must have a value. 2. All records within a file must reflect the same PROTOCOL_ID value. 	
<i>Optional validation rules for this attribute:</i>	<ol style="list-style-type: none"> 1. Should begin with the string "KM-2". 	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> GPS_STATUS	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> GPS Status	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> The GPS unit's current fix quality, as reported in the NMEA GGA sentence. The most interesting include: 0 – invalid 1 – GPS fix (SPS) 2 – DGPS fix		
<i>Data type:</i>	Varchar(1)	
<i>Maximum length</i>	1	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must be a digit between 0 and 8. 	
<i>Optional validation rules for this attribute:</i>	<ol style="list-style-type: none"> 1. Should be '0', '1', or '2'. 	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> SATELLITES	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Satellites	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> The number of satellites acquired by the GPS unit when reporting the current location.		
<i>Data type:</i>	Varchar(2)	
<i>Maximum length</i>	2	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must represent an integer between 0 and 99.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> HDOP	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> HDOP	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> The Horizontal Degree of Precision reported by GPS unit when fixing the current location. 1.0 is ideal, 1.0-2.0 excellent, 2.0-5.0 good, 5.0-10.0 moderate, 10.0-20.0 fair, >20 poor.		
<i>Data type:</i>	Varchar(4)	
<i>Maximum length</i>	4	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	99.9	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must represent a real number between 0.0 and 99.9.	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> TRACK_LENGTH	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Transect Length	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> The actual length in meters covered when traversing a particular transect this year. It is calculated by summing the distances between individual consecutive trackpoints whose ON_TRANSECT value is True. If a transect is surveyed multiple times in a calendar year, TRACK_LENGTH will be one number reflecting the total distance covered in all attempts.		
<i>Data type:</i>	Varchar(16)	
<i>Maximum length</i>	16	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	9999999999999999 with embedded decimal	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must represent a positive real number.	
<i>Optional validation rules for this attribute:</i>	1. Should be between 1,000.0 and 15,000.0	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> COMMENTS	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Comments	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> Freeform text describing exceptions.		
<i>Data type:</i>	Varchar(1024)	
<i>Maximum length</i>	1024	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> DATA_QUALITY	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Data Quality Code	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> A code indicating the gross data quality: 0 – Good: no exceptions encountered. 1 – Unknown quality: not possible to judge due to lack of information. 4 – Questionable: see comment to determine if it is suitable for a particular purpose. 8 – Bad: cannot be used Note rows marked as Bad are not added to the KM_E database.		
<i>Data type:</i>	Varchar(1)	
<i>Maximum length</i>	1	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	9	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present, must be a single digit.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> DATA_QUALITY_COMMENT	<i>Used by deliverable ID:</i> KM_D
<i>Revision date / protocol version:</i> 06-14-2011 / 2012.1	<i>Default report heading:</i> Quality Comment	<i>Relation (from Form X):</i> KM_D_yyyy.CSV
<i>Purpose:</i> An explanation of the basis for assigning this record a DATA_QUALITY of greater than one. If multiple issues exist, it is preferred a separate sentence be provided for each issue.		
<i>Data type:</i>	Varchar(1024)	
<i>Maximum length</i>	1024	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

H.5 KM_E: Cumulative Observation Database

Purpose of deliverable: Working with groups of individual KM_D CSV files can be cumbersome and difficult. A SQL database is maintained that contains all the observed values from all surveys in the monitoring program. These rows may differ slightly from KM_D data in reflecting data quality information, outlier corrections, etc. Through the web, the database may be queried to produce a file on the customer's workstation containing final data, filtered to meet the customer's exact area of interest. Deliverable KM_E is an incremental update used to revise the cumulative database for each particular calendar year.

Frequency produced: KM_E is generated at the end of each season directly after certification of KM_D corrected data files.

Prerequisites: Production of this deliverable is dependent on having a certified KM_D product for the year. It is created directly from KM_D certified files by an automated application.

Data flow:

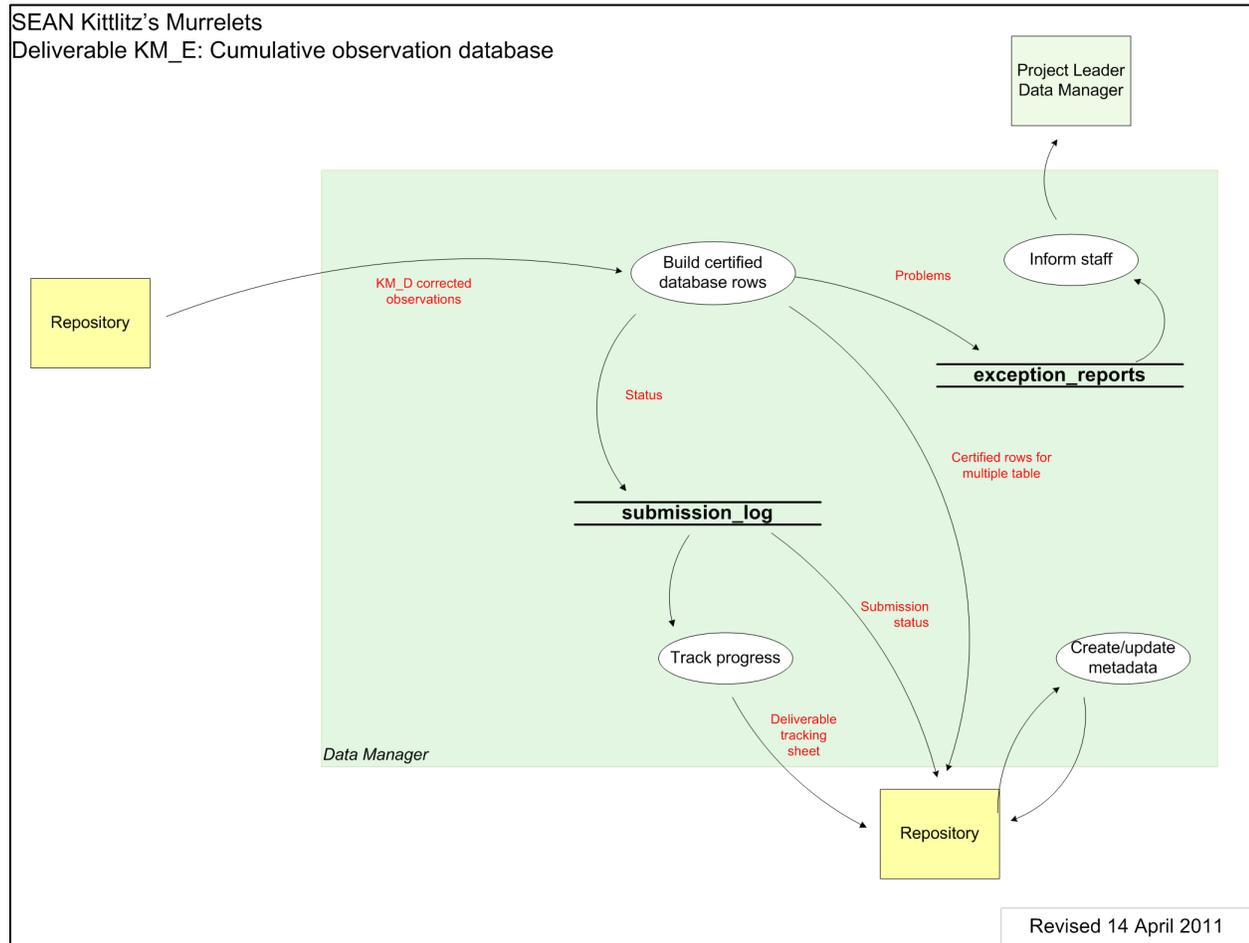


Figure H.5. Data flow required to generate deliverable KM_E – Cumulative Observation Database.

Deliverable definition forms:

Form D: Tabular Data Deliverable

<i>Vital Sign:</i> KM Kittlitz’s murrelets	<i>Deliverable ID:</i> KM_E	<i>Deliverable Title:</i> Cumulative Database
<i>File format:</i> n/a	<i>Associated software and version:</i> n/a	<i>Revision Date / protocol version:</i> 10-01-2012 / 2012.1
<i>Expected frequency:</i> 1 submission/year	<i>Likely dissemination partners:</i> None – served by SEAN	<i>Submission unit:</i> YEAR
<p><i>What purpose does this deliverable serve?</i> Provides tracklog of murrelet surveys in Glacier Bay, including individual survey observations. This is basically a concatenation of all years of deliverable KM_D recast in a database structure. Also included is the TRANSECT_SCOPE table extracted from KM_A, which is typically static and does not change over years.</p>		
<p><i>Identifiers of relations that compose the tabular deliverable (“Relations” are tables or files that provide information which may be represented in a grid format. Each relation listed must be fully defined in its own accompanying Form X.):</i> tbl_km_observation</p>		
<p><i>Deliverable ID of any other SEAN data products required to create this product:</i> KM_A KM_D</p>		
<p><i>Description and source of any outside data required to create this product:</i> - none -</p>		

Form X: Relation Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Relation identifier:</i> tbl_km_observation	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Type of relation:</i> Database Table	<i>Estimated rows:</i> 50,000/year
<i>Primary key for this relation:</i> date_local + time_local		
<p><i>Purpose:</i> The GPS tracklog generated along murrelet survey transects. At those particular points where an observation is made, the angle, distance, behavior, group size, and species are present – elsewhere these are null. The table is totally denormalized to facilitate web downloading and direct use by Excel and MS Access.</p> <p>Note: this is built automatically from certified KM_D products. Mandatory validation is enforced to be certain any underlying KM_D has not been corrupted. Optional criteria have already been evaluated during KM_D certification, so no optional validation criteria are checked on KM_E.</p>		
<i>Identifiers of attributes defined over this relation ("Attributes" are columns of the grid. Each attribute must be defined in an accompanying Form Y.):</i>		
TRANSECT_ID	DATE_LOCAL	
TIME_LOCAL	VESSEL	
RECORDER	OBSERVER_1	
OBSERVER_2	BEAUFORT	
WEATHER_CODE	VISIBILITY	
LATITUDE_WGS84	LONGITUDE_WGS84	
UTM8_EASTING	UTM8_NORTHING	
SPEED	BEARING	
ANGLE	DISTANCE	
BEHAVIOR	GROUP_SIZE	
SPECIES	ON_TRANSECT	
PROTOCOL_ID	GPS_STATUS	
SATELLITES	HDOP	
TRACK_LENGTH	COMMENTS	
DATA_QUALITY	DATA_QUALITY_COMMENT	
TIME_STAMP	USERID	
SUBMISSION_NUMBER		
<i>Mandatory validation criteria involving multiple attributes:</i> - none -		
<i>Optional validation criteria involving multiple attributes:</i> - none -		

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> TRANSECT_ID	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Transect	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> Identifier used to designate a particular survey transect on which data were collected. The specific transect IDs employed in a survey are permanently defined, but transects surveyed vary by year.		
<i>Data type:</i>	Varchar(24)	
<i>Maximum length</i>	24	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	tbl_transect_scope.transect_id	
<i>Case:</i>	Ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> DATE_LOCAL	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Date	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> Date the trackpoint or survey observation was recorded; in the local ADT time zone.		
<i>Data type:</i>	Date	
<i>Maximum length</i>	n/a	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must represent a valid a date. 2. Must not be a date beyond the current one at point of validation. 3. Must not be a date before 2009. 	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

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<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> TIME_LOCAL	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Time	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> Time the trackpoint or observation was recorded; in the local ADT time zone and expressed using a 24-hour clock.		
<i>Data type:</i>	Time	
<i>Maximum length</i>	n/a	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must represent a valid a time.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> VESSEL	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-04-2011 / 2012.1	<i>Default report heading:</i> Vessel	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> The name of the boat used to survey this transect.		
<i>Data type:</i>	Varchar(24)	
<i>Maximum length</i>	24	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	Ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> RECORDER	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-04-2011 / 2012.1	<i>Default report heading:</i> Recorder	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> The name of the person who operated the data recording station (Data Recorder) on this transect, typically as initials.		
<i>Data type:</i>	Varchar(24)	
<i>Maximum length</i>	24	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	Ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> OBSERVER_1	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-04-2011 / 2012.1	<i>Default report heading:</i> First observer	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> The name of the first survey Observer on this transect (typically as initials). OBSERVER_1 is used when a single person conducts the survey. OBSERVER_1 denotes the left (port) side Observer when two are used.		
<i>Data type:</i>	Varchar(24)	
<i>Maximum length</i>	24	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	Ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> OBSERVER_2	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-04-2011 / 2012.1	<i>Default report heading:</i> Second observer	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> The name of the second survey Observer (typically as initials), on the right (starboard) side of the vessel. Used only when surveys are conducted by two Observers.		
<i>Data type:</i>	Varchar(24)	
<i>Maximum length</i>	24	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	Ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> BEAUFORT	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Beaufort sea state	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> Estimate of sea state encountered on a transect using the Beaufort scale: 0 – Calm / Flat. 1 – Light air / Ripples without crests. 2 – Light breeze / Small wavelets. Crests of glassy appearance, not breaking. 3 – Gentle breeze / Large wavelets. Crests begin to break; scattered whitecaps.		
<i>Data type:</i>	Varchar(1)	
<i>Maximum length</i>	1	
<i>Required:</i>	no	
<i>Measurement units:</i>	Beaufort scale designators	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present, must be one of '0', '1', '2', or '3'.	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> WEATHER_CODE	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Weather conditions	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> Observed weather using the following encoding: 0 – Less than 50% cloud cover. 1 – Greater than 50% cloud cover. 2 – Fog. 3 – Mist. 4 – Rain.		
<i>Data type:</i>	Varchar(1)	
<i>Maximum length</i>	1	
<i>Required:</i>	no	
<i>Measurement units:</i>	Proprietary coding	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present, must be one of '0', '1', '2', '3', or '4'.	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> VISIBILITY	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Visibility	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> Visibility using the following encoding: 1 – Greater than 500 meters. 2 – Between 250 and 500 meters. 3 – Less than 250 meters.		
<i>Data type:</i>	Varchar(1)	
<i>Maximum length</i>	1	
<i>Required:</i>	no	
<i>Measurement units:</i>	Proprietary coding	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present, must be one of '1', '2', or '3'.	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> LATITUDE_WGS84	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Latitude	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> Latitude of vessel in decimal degrees using the WGS84 datum.		
<i>Data type:</i>	real	
<i>Maximum length</i>	11	
<i>Required:</i>	yes	
<i>Measurement units:</i>	Decimal degrees	
<i>Format:</i>	99.99999999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must represent a valid real number. 2. Must be between 58.0 and 60.0. 	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> LONGITUDE_WGS84	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Longitude	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> Longitude of vessel in decimal degrees using the WGS84 datum.		
<i>Data type:</i>	real	
<i>Maximum length</i>	13	
<i>Required:</i>	yes	
<i>Measurement units:</i>	Decimal degrees	
<i>Format:</i>	-999.99999999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must represent a valid real number. 2. Must be between -135.0 and -138.0. 	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> UTM8_EASTING	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Easting	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> Longitude of vessel as expressed in meters using the Universal Transverse Mercator coordinate system for zone 8N and NAD83 datum.		
<i>Data type:</i>	real	
<i>Maximum length</i>	11	
<i>Required:</i>	no	
<i>Measurement units:</i>	Meters	
<i>Format:</i>	999999.9999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must represent a valid real number.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> UTM8_NORTHING	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Northing	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> Latitude of vessel as expressed in meters using the Universal Transverse Mercator coordinate system for zone 8N and NAD83 datum.		
<i>Data type:</i>	real	
<i>Maximum length</i>	12	
<i>Required:</i>	no	
<i>Measurement units:</i>	Meters	
<i>Format:</i>	9999999.9999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must represent a valid real number.	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> SPEED	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Boat speed	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> The momentary speed of the vessel in kilometers/hour as calculated by the GPS unit.		
<i>Data type:</i>	real	
<i>Maximum length</i>	10	
<i>Required:</i>	no	
<i>Measurement units:</i>	Km/h	
<i>Format:</i>	99.9999999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present, must represent a valid real number.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> BEARING	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Bearing	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> Bearing of boat in degrees as calculated by the GPS unit, with true north being 0 degrees.		
<i>Data type:</i>	real	
<i>Maximum length</i>	12	
<i>Required:</i>	no	
<i>Measurement units:</i>	Decimal degrees	
<i>Format:</i>	999.99999999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present, must be between 0.0 and 359.99999999.	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> ANGLE	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Angle	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> Angle of observed group from the survey Observer relative to a line running through the center of the boat from bow to stern with port being 90, forward 180, starboard 270, and aft 0 degrees.		
<i>Data type:</i>	integer	
<i>Maximum length</i>	3	
<i>Required:</i>	no	
<i>Measurement units:</i>	Degrees	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must represent an integer between 1 and 359.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> DISTANCE	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Distance	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> Estimated distance in meters from the Observer to center of observed bird group.		
<i>Data type:</i>	integer	
<i>Maximum length</i>	3	
<i>Required:</i>	no	
<i>Measurement units:</i>	Meters	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present, must represent an integer between 1 and 500.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> BEHAVIOR	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Behavior	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> Indicator of whether the observed group is flying or on the water. While recorded in initial survey years, the value is limited to 'W' in current practice. A group may consist of only one species with one behavior.		
<i>Data type:</i>	Varchar(1)	
<i>Maximum length</i>	1	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present, must be 'F', or 'W'.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> GROUP_SIZE	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Group Size	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> Number of individuals (of one species) in the observed groups.		
<i>Data type:</i>	integer	
<i>Maximum length</i>	2	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present, must represent an integer between 1 and 99.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> SPECIES	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Species	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> Indicator of species for this group observed. A group may consist of only one species. K - Kittlitz's murrelet M – Marbled murrelet U – Unknown		
<i>Data type:</i>	Varchar(1)	
<i>Maximum length</i>	1	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present must be 'K', 'M', or 'U'.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> ON_TRANSECT	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> On Transect	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> Set to "True" if the current record was taken while following the designated transect for the survey. Set "False" if off transect, as at initial approach or when avoiding a hazard. This is required in order to support calculating the exact track length covered for a transect.		
<i>Data type:</i>	Varchar(5)	
<i>Maximum length</i>	5	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must be 'False' or 'True'.	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> PROTOCOL_ID	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Protocol	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> The formal version identifier of the monitoring protocol document that was observed during the collection of these data. For example, "KM-2012.1".		
<i>Data type:</i>	Varchar(10)	
<i>Maximum length</i>	10	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	tbl_protocol.protocol	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must match a protocol in tbl_protocol	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> GPS_STATUS	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> GPS Status	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> The GPS unit's current fix quality, as reported in the NMEA GGA sentence. The most interesting include: 0 – invalid 1 – GPS fix (SPS) 2 – DGPS fix		
<i>Data type:</i>	Varchar(1)	
<i>Maximum length</i>	1	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present, must be a digit between 0 and 8.	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> SATELLITES	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Satellites	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> The number of satellites acquired by the GPS unit when reporting the current location.		
<i>Data type:</i>	integer	
<i>Maximum length</i>	2	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present, must represent an integer between 0 and 99.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> HDOP	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> HDOP	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> The Horizontal Degree of Precision reported by GPS unit when fixing the current location. 1.0 is ideal, 1.0-2.0 excellent, 2.0-5.0 good, 5.0-10.0 moderate, 10.0-20.0 fair, >20 poor.		
<i>Data type:</i>	real	
<i>Maximum length</i>	4	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	99.9	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present, must represent a real number between 0.0 and 99.9.	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> TRACK_LENGTH	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Transect Length	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> The actual length in meters covered when traversing a particular transect this year. It is calculated by summing the distances between individual consecutive trackpoints whose ON_TRANSECT value is True. If a transect is surveyed repeatedly in a calendar year, TRACK_LENGTH will be one number reflecting the total distance covered in all attempts.		
<i>Data type:</i>	real	
<i>Maximum length</i>	16	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	9999999999999999 with embedded decimal	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present, must represent a positive real number.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> COMMENTS	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Comments	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> Freeform text describing exceptions.		
<i>Data type:</i>	Varchar(1024)	
<i>Maximum length</i>	1024	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> DATA_QUALITY	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Data Quality Code	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> A code indicating the gross data quality: 0 – Good: no exceptions encountered. 1 – Unknown quality: not possible to judge due to lack of information. 4 – Questionable: see comment to determine if it is suitable for a particular purpose. 8 – Bad: cannot be used Note rows marked as Bad in the input submission are not added to the KM_E database.		
<i>Data type:</i>	Varchar(1)	
<i>Maximum length</i>	1	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	9	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. If present, must be a single digit.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> DATA_QUALITY_COMMENT	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Quality Comment	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> An explanation of the basis for assigning this record a DATA_QUALITY of greater than one. If multiple issues exist, it is preferred a separate sentence be provided for each issue.		
<i>Data type:</i>	Varchar(1024)	
<i>Maximum length</i>	1024	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> TIME_STAMP	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Last Updated	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> The date and time this row was most recently inserted or updated in the table. It is used for auditing purposes.		
<i>Data type:</i>	datetime	
<i>Maximum length</i>	n/a	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> USERID	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Updated by	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> The login name used to authorize the process that created/updated this row in the cumulative database. It is restricted to those userids stored in the database table called tbl_submitter. It is used for auditing purposes.		
<i>Data type:</i>	Varchar(20)	
<i>Maximum length</i>	20	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	tbl_submitter.submitter_userid	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must match a userid in tbl_submitter.	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> SUBMISSION_NUMBER	<i>Used by deliverable ID:</i> KM_E
<i>Revision date / protocol version:</i> 06-19-2012 / 2012.1	<i>Default report heading:</i> Submission#	<i>Relation (from Form X):</i> tbl_km_observation
<i>Purpose:</i> The submission number used to transmit to the network the files from which this particular row came. It is used for several data management purposes, including auditing.		
<i>Data type:</i>	int	
<i>Maximum length</i>	n/a	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	tbl_submission_log.submission_number	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must match a submission_number in tbl_submission_log.	
<i>Optional validation rules for this attribute:</i>	- none -	

H.6 KM_F: Annual Report

Purpose of deliverable: This report summarizes operations and outcomes for each survey year. Analyses include descriptive statistics summarizing survey effort and characteristics of the sample, estimates of component parameters used for population estimates (detection probability, group size, encounter rates), estimates of on-water density and abundance for each murrelet species, and maps summarizing spatial distributions of populations.

Frequency produced: Once per year, after completion of each field season.

Prerequisites: Certified KM_A transect definition deliverable. Certified database deliverable KM_E for the season.

Data flow:

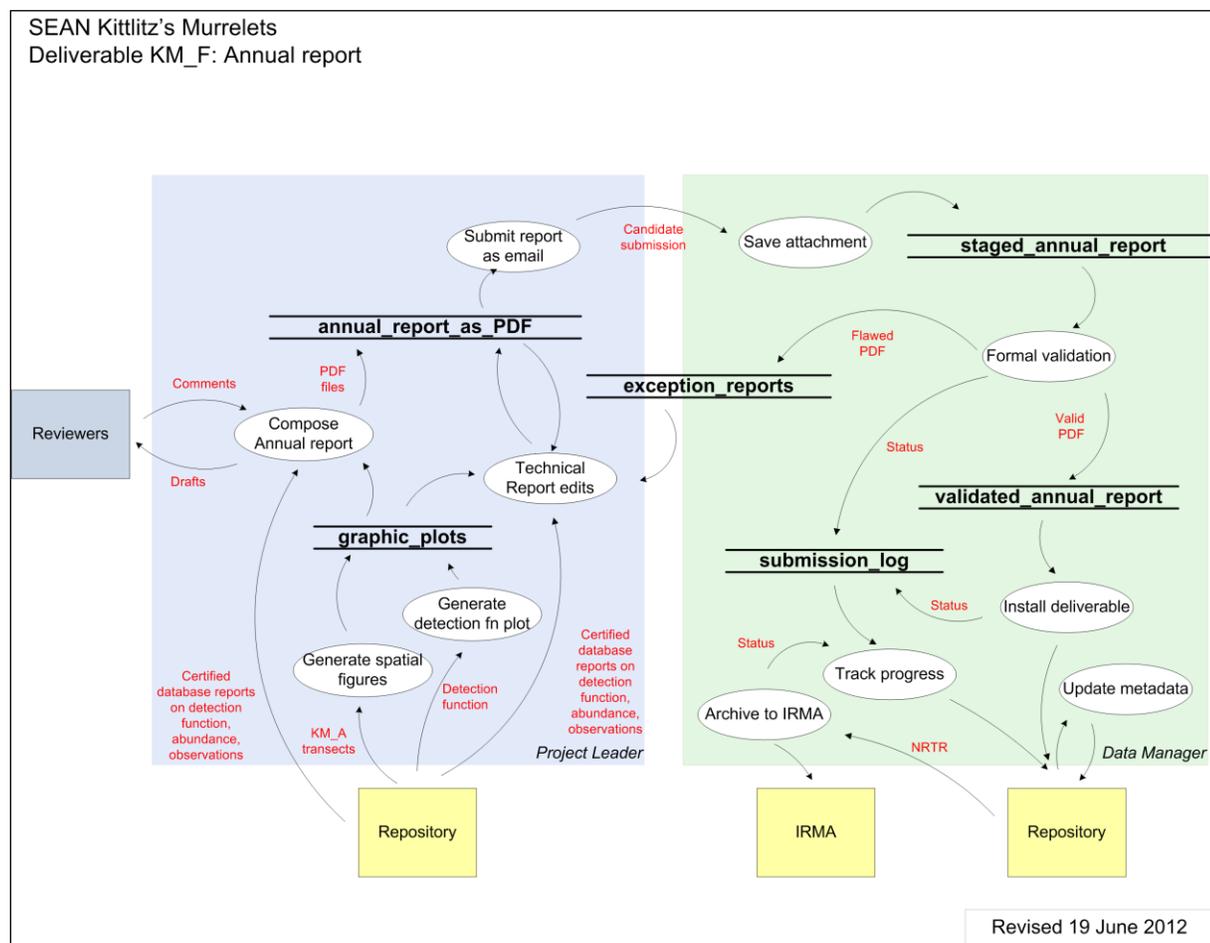


Figure H.6. Data flow required to generate deliverable KM_F – Annual Report.

Deliverable definition forms:

Form A: Non-Tabular Information Deliverable

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Deliverable ID:</i> KM_F	<i>Deliverable Title:</i> Annual report
<i>File format:</i> PDF	<i>Associated software and version:</i> Adobe Reader 11	<i>Revision Date / protocol version:</i> 06-19-2012 / 2012.1
<i>Expected frequency:</i> 1/year	<i>Likely dissemination partners:</i> None – served by SEAN	<i>Submission unit:</i> Year
<i>What purpose does this deliverable serve?</i> Summarizes operations and outcomes of each survey year to inform resource managers, scientists and the public.		
<i>Summary of content:</i> Descriptive statistics summarizing survey effort and characteristics of the sample, estimates of component parameters used to estimate density (detection probability, group size, encounter rates), estimates of density and abundance for each murrelet species, and maps summarizing spatial distributions of populations.		
<i>Mandatory validation criteria:</i> 1. Must successfully open using Adobe Reader 11.0 or greater.		
<i>Optional validation criteria:</i> - none -		
<i>Deliverable ID of any other SEAN data products required to create this product</i> KM_A transect definitions. KM_E database rows.		
<i>Description and source of any outside data required to create this product:</i> - none -		

H.7 KM_G: Periodic Review

Purpose of deliverable: Primary objectives for periodic reviews are to 1) estimate population trend for Kittlitz's and marbled murrelets 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 goals, and 5) recommend changes to the protocol. Additional objectives may be defined to meet specific needs, such as developing or adopting improved survey or analytic methods or conducting research targeting critical information gaps.

Frequency produced: As needed. Typically once every six years.

Prerequisites: A multi-year consistent time series of observations from the certified KM_E deliverable.

Data flow:

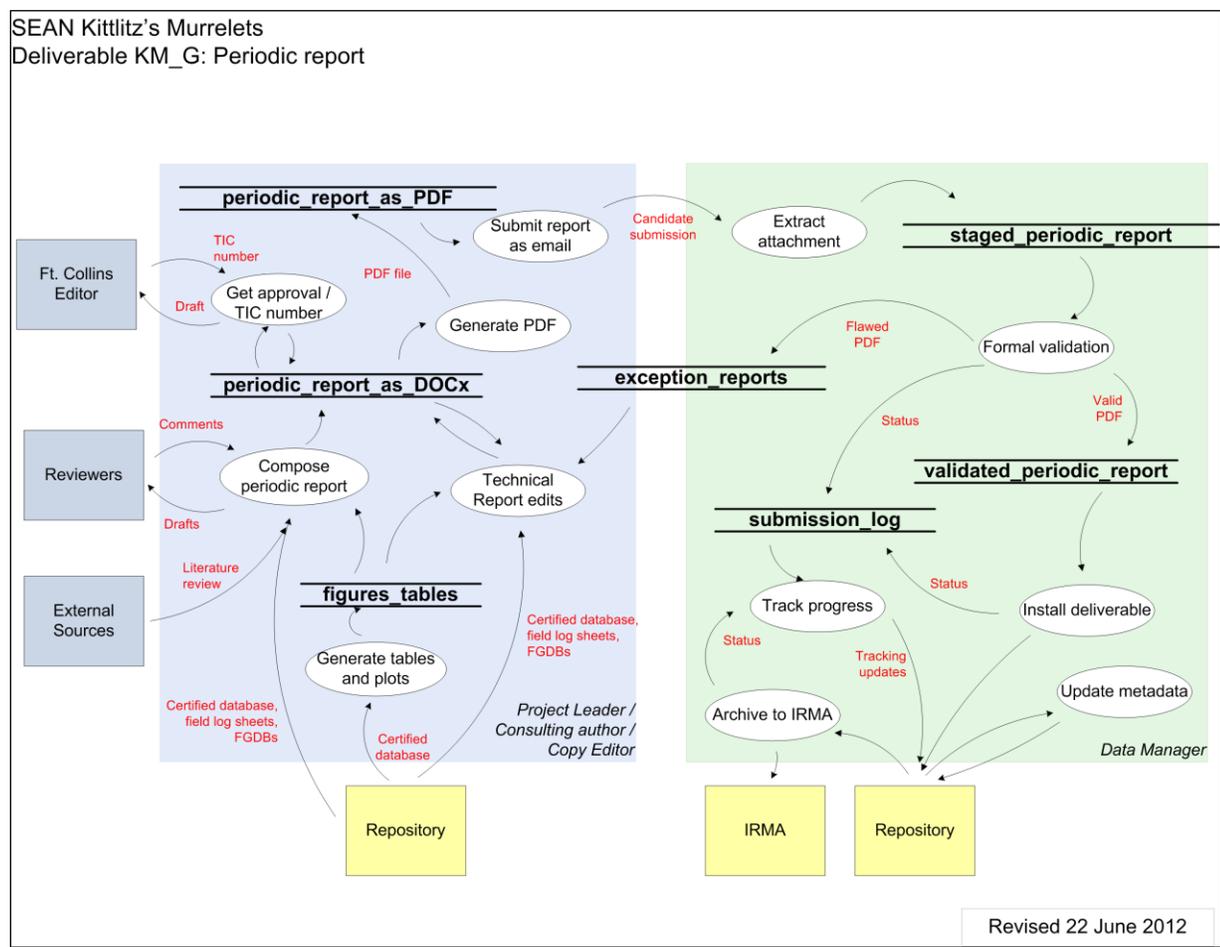


Figure H.7. Data flow required to generate deliverable KM_G – Periodic Review.

Deliverable definition forms:

Form A: Non-Tabular Information Deliverable

<i>Vital Sign:</i> KM Kittlitz’s murrelets	<i>Deliverable ID:</i> KM_G	<i>Deliverable Title:</i> Periodic review
<i>File format:</i> PDF	<i>Associated software and version:</i> Adobe Reader 11	<i>Revision Date / protocol version:</i> 06-19-2012 / 2012.1
<i>Expected frequency:</i> Once every 5 years	<i>Likely dissemination partners:</i> None – served by SEAN	<i>Submission unit:</i> Publication year
<i>What purpose does this deliverable serve?</i> Primary objectives for periodic reviews are to 1) estimate population trend for Kittlitz’s and marbled murrelets 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 goals, and 5) recommend changes to the protocol. Additional objectives may be defined to meet specific needs, such as developing or adopting improved survey or analytic methods or conducting research targeting critical information gaps.		
<i>Summary of content:</i> <ol style="list-style-type: none"> 1. Introduction: Overview of prior results of the murrelet monitoring program and the objectives and methods of the periodic review. 2. Methods: Brief summary monitoring methods and more detailed information on analytic methods used in the periodic review. 3. 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. 4. 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. 5. Recommendations: Recommended refinements to the monitoring protocol or issues requiring further consideration (e.g., in targeted research or a subsequent periodic review). 6. Literature Review (optional): Summary of literature (emphasizing recent literature) with implications for the monitoring program or conservation of murrelets in Glacier Bay. 		
<i>Mandatory validation criteria:</i> <ol style="list-style-type: none"> 1. Must successfully open using Adobe Reader 11.0 or greater. 		
<i>Optional validation criteria:</i> - None -		
<i>Deliverable ID of any other SEAN data products required to create this product</i> KM_E cumulative database		
<i>Description and source of any outside data required to create this product:</i> Determined at time of analysis		

H.8 KM_H: Protocol

Purpose of deliverable: The protocol document defines in detail the technical methodology employed in the SEAN Kittlitz's murrelet monitoring program.

Frequency produced: Created as needed, using the processes defined in SOP 8.

Prerequisites: Protocol deliverables are always built on the DOCX form of the latest published KM_H protocol document.

Data flow:

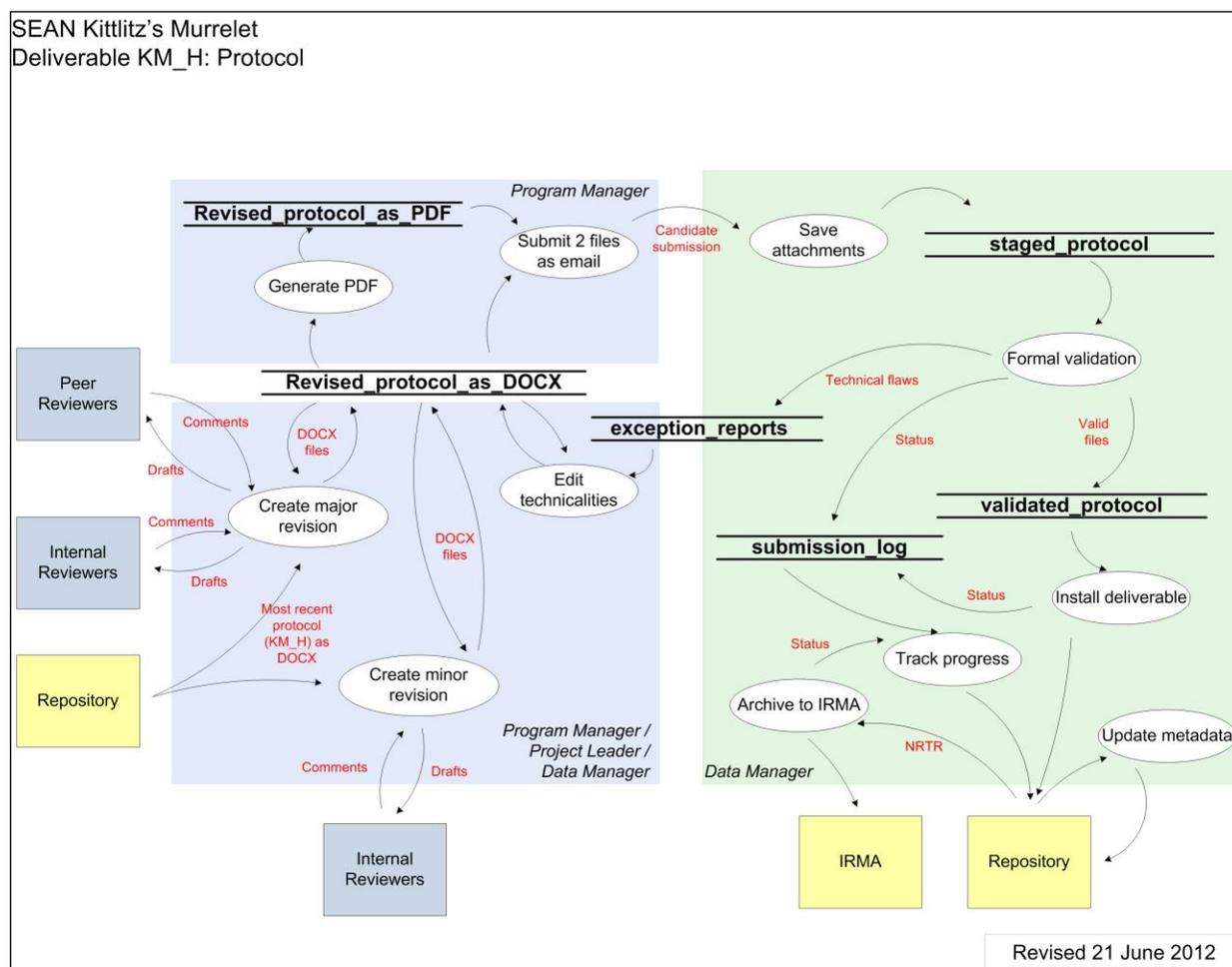


Figure H.8. Data flow required to generate deliverable KM_H – Protocol.

Deliverable definition forms:

Form A: Non-Tabular Information Deliverable

<i>Vital Sign:</i> KM Kittlitz’s murrelets	<i>Deliverable ID:</i> KM_H	<i>Deliverable Title:</i> Protocol
<i>File format:</i> DOCX and PDF	<i>Associated software and version:</i> Word 2010 + Adobe Acrobat 11	<i>Revision Date / protocol version:</i> 06-21-2012/ KM-2012.1
<i>Expected frequency:</i> unknown	<i>Likely dissemination partners:</i> None – served by SEAN	<i>Submission unit:</i> N/A: a single unit to supplant the existing KM_H.
<i>What purpose does this deliverable serve?</i> Defines the technical methodology employed in the SEAN Kittlitz’s murrelet monitoring program.		
<i>Summary of content:</i> Narrative, detailed appendices, standard operating procedures for conducting program. A PDF copy is kept for dissemination purposes. A DOCX copy is kept as the basis for the next version update.		
<i>Mandatory validation criteria:</i> <ol style="list-style-type: none"> 1. PDF must successfully open using Adobe Reader 11.0 or greater. 2. DOCX must successfully open using Microsoft Word 2010. 3. Must consistently reference a correct version number, as defined in SEAN Data Management Plan (Johnson and Moynahan 2008: SOP 602 – Version Control). 		
<i>Optional validation criteria:</i> - none -		
<i>Deliverable ID of any other SEAN data products required to create this product</i> Most recent prior KM_H.		
<i>Description and source of any outside data required to create this product:</i> No specific sources can be named in advance. Editors will have to draw on a number of areas of technical expertise and guidance to complete this deliverable.		

H.9 KM_I: Waypoints

Purpose of deliverable: One GPS device is used during the course of a field season to record locations of interest as waypoints. Such locations may include transect extents and places where exceptions were encountered. These may be useful in resolving data quality issues during post-field processing.

Frequency produced: KM_I is created at the end of each season by generating a comma-delimited ASCII file from the GPS unit.

Prerequisites: None.

Data flow:

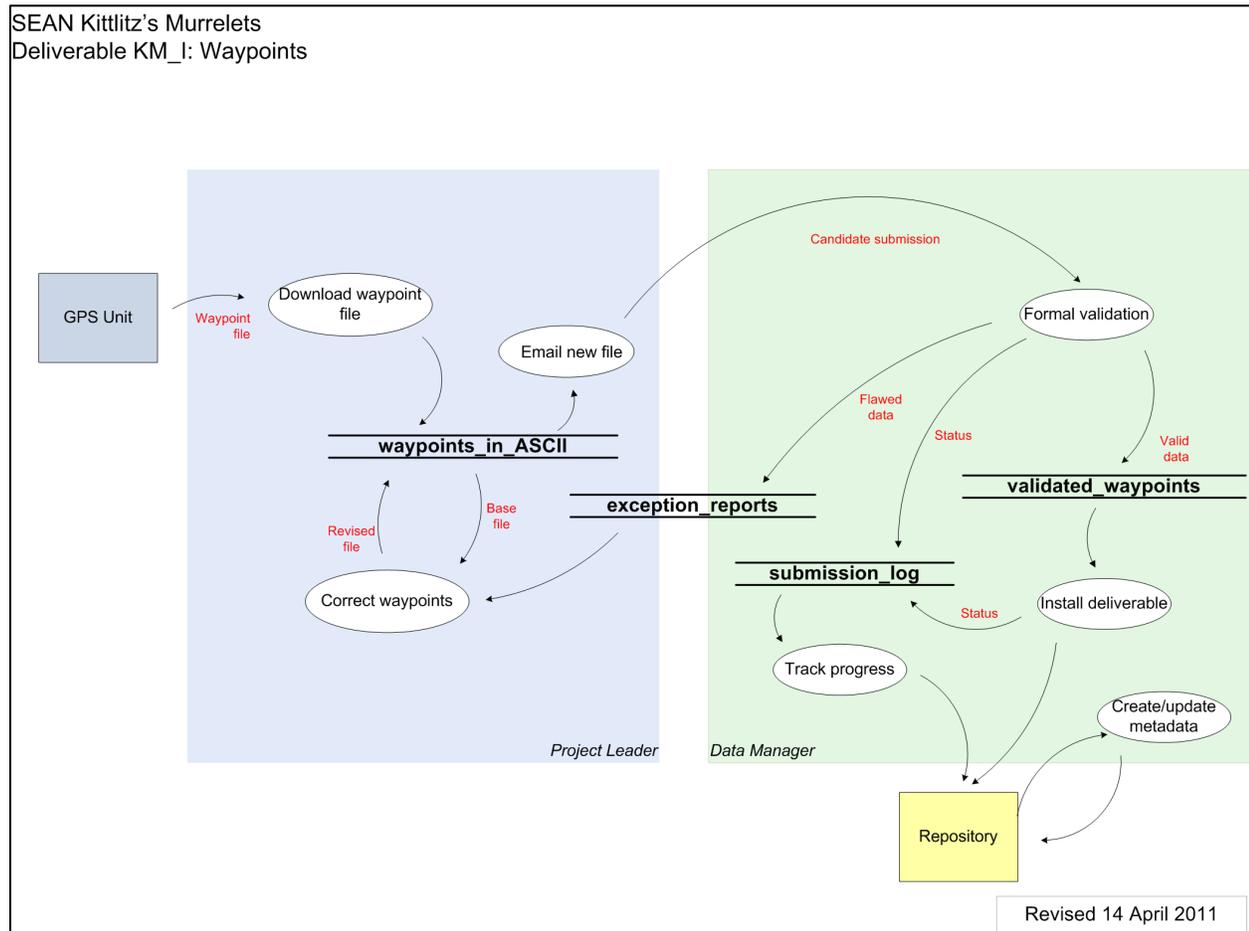


Figure H.9. Data flow required to generate deliverable KM_I – Waypoints.

Deliverable definition forms:

Form D: Tabular Data Deliverable

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Deliverable ID:</i> KM_I	<i>Deliverable Title:</i> Waypoints
<i>File format:</i> Comma delimited ASCII text with first line containing column names for rest of file	<i>Associated software and version:</i> None	<i>Revision Date / protocol version:</i> 05-05-2011 / 2012.1
<i>Expected frequency:</i> 1 file/year	<i>Likely dissemination partners:</i> None – served by SEAN	<i>Submission unit:</i> YEAR
<i>What purpose does this deliverable serve?</i> Provides the GPS waypoints noted (for various purposes) during one year.		
<i>Identifiers of relations that compose the tabular deliverable ("Relations" are tables or files that provide information which may be represented in a grid format. Each relation listed must be fully defined in its own accompanying Form X.):</i> KM_I_yyyy.CSV is an ASCII text file created by the GPS unit.		
<i>Deliverable ID of any other SEAN data products required to create this product:</i> - none -		
<i>Description and source of any outside data required to create this product:</i> Waypoint file maintained inside GPS unit.		

Form X: Relation Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Relation identifier:</i> KM_I_YYYY.CSV	<i>Used by deliverable ID:</i> KM_I					
<i>Revision date / protocol version:</i> 05-05-2011 / 2012.1	<i>Type of relation:</i> <input type="radio"/> Database table <input type="radio"/> Data file	<i>Estimated rows:</i> 350/file					
<i>Primary key for this relation:</i> <ul style="list-style-type: none"> • none - 							
<i>Purpose:</i> GPS waypoint locations taken during field work.							
<i>Identifiers of attributes defined over this relation ("Attributes" are columns of the grid. Each attribute must be defined in an accompanying Form Y.):</i> The first line of the file contains the special attribute <table border="1" style="width: 100%;"> <tr> <td>HEADER</td> </tr> </table> The remaining lines contain these useful attributes: <table border="1" style="width: 100%;"> <tr> <td>WAYPOINT_ID</td> <td>LATITUDE</td> </tr> <tr> <td>LONGITUDE</td> <td>TIMESTAMP</td> </tr> </table>			HEADER	WAYPOINT_ID	LATITUDE	LONGITUDE	TIMESTAMP
HEADER							
WAYPOINT_ID	LATITUDE						
LONGITUDE	TIMESTAMP						
Each line in the file contains additional data generated by the GPS, which is not useful and requires no validation.							
<i>Mandatory validation criteria involving multiple attributes:</i> <ul style="list-style-type: none"> • none - 							
<i>Optional validation criteria involving multiple attributes:</i> <ul style="list-style-type: none"> • none - 							

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> HEADER	<i>Used by deliverable ID:</i> KM_I
<i>Revision date / protocol version:</i> 05-05-2011 / 2012.1	<i>Default report heading:</i> - None -	<i>Relation (from Form X):</i> KM_I_YYYY.CSV
<i>Purpose:</i> String containing column names for remaining data in file.		
<i>Data type:</i>	Varchar(200)	
<i>Maximum length</i>	200	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	Unformatted string	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	Ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must contain all of the following substrings: "WAYPOINT_ID", "LATITUDE", "LONGITUDE", "TIMESTAMP".	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> WAYPOINT_ID	<i>Used by deliverable ID:</i> KM_I
<i>Revision date / protocol version:</i> 05-05-2011 / 2012.1	<i>Default report heading:</i> Waypoint	<i>Relation (from Form X):</i> KM_I_YYYY.CSV
<i>Purpose:</i> Unique ID string denoting an individual waypoint.		
<i>Data type:</i>	Varchar(24)	
<i>Maximum length</i>	24	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	Unformatted string	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	Ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must be unique within the relation.	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> LATITUDE	<i>Used by deliverable ID:</i> KM_I
<i>Revision date / protocol version:</i> 05-05-2011 / 2012.1	<i>Default report heading:</i> Latitude	<i>Relation (from Form X):</i> KM_I_yyyy.CSV
<i>Purpose:</i> Decimal latitude in WGS84 datum.		
<i>Data type:</i>	Varchar(12)	
<i>Maximum length</i>	12	
<i>Required:</i>	yes	
<i>Measurement units:</i>	degrees	
<i>Format:</i>	99.999999999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must represent a valid real number. 2. Must be between 58.0 and 60.0. 	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> LONGITUDE	<i>Used by deliverable ID:</i> KM_I
<i>Revision date / protocol version:</i> 05-05-2011 / 2012.1	<i>Default report heading:</i> Longitude	<i>Relation (from Form X):</i> KM_I_yyyy.CSV
<i>Purpose:</i> Decimal longitude using the WGS84 datum.		
<i>Data type:</i>	Varchar(12)	
<i>Maximum length</i>	12	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	-999.9999999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must represent a valid real number. 2. Must be between -135.0 and -138.0. 	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> TIMESTAMP	<i>Used by deliverable ID:</i> KM_I
<i>Revision date / protocol version:</i> 05-05-2011 / 2012.1	<i>Default report heading:</i> Date / Time	<i>Relation (from Form X):</i> KM_I_YYYY.CSV
<i>Purpose:</i> Date the waypoint was taken; in the GMT zone.		
<i>Data type:</i>	Varchar(24)	
<i>Maximum length</i>	24	
<i>Required:</i>	no	
<i>Measurement units:</i>	Date and time	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. If present, must represent a valid a date. 2. If present, must not be a date beyond the current one at point of validation. 3. If present, must not have a year before 2009. 	
<i>Optional validation rules for this attribute:</i>	<ol style="list-style-type: none"> 1. Month part of date should be between May and August 	

H.10 KM_J: Detection Function

Purpose of deliverable: Estimation of a detection function that provides estimates detection probability for murrelet groups relative to the perpendicular distance from the transect center line. Also, provides estimates of group size for each murrelet species. Program DISTANCE is used for estimation. Associated parameters are then used by KM_K to produce population estimates. This deliverable consists of a ZIP file containing DISTANCE output files and a graphic plot of detection function. Once certified, DISTANCE output is also stored in the SEAN database for later use in creating KM_K.

Frequency produced: Once per year, after completion of each field season.

Prerequisites: Certified database deliverable KM_E for the season.

Data flow:

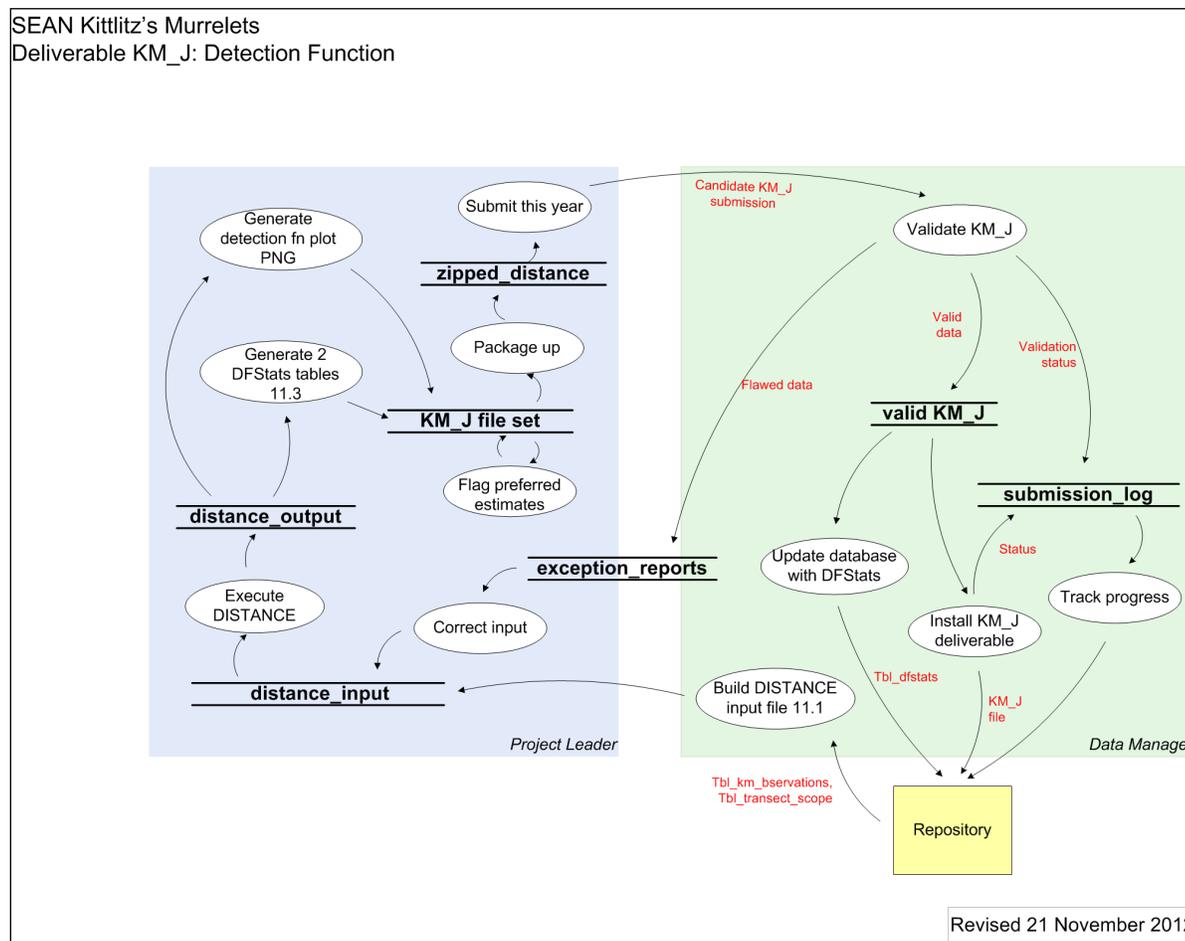


Figure H.10. Data flow required to generate deliverable KM_J – Detection function.

Deliverable definition forms:

Form A: Non-Tabular Information Deliverable

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Deliverable ID:</i> KM_J	<i>Deliverable Title:</i> Detection Function
<i>File format:</i> ZIP	<i>Associated software and version:</i> PKZip, etc.	<i>Revision Date / protocol version:</i> 10-31-2012 / 2012.1
<i>Expected frequency:</i> 1/year	<i>Likely dissemination partners:</i> None – served by SEAN	<i>Submission unit:</i> Year
<i>What purpose does this deliverable serve?</i> Documents the estimated detection function and group sizes for each survey year, precursors to estimating population abundance and density.		
<i>Summary of content:</i> Descriptive statistics and parameter estimates related to estimation of a detection function and group sizes for each survey year. KM_J is a ZIP file containing three files: DFStats – containing results for analyses of population trend, DFStats_status – containing results for analyses of population status, and DFPlot –containing a graph of the estimated detection function. The constituent files are defined below as Subpart A, Subpart B, and Subpart C respectively.		
<i>Mandatory validation criteria:</i> <ol style="list-style-type: none"> 1. Must successfully open using WinZip, PKZip, or equivalent. 2. Must contain three files with the following names: DFStats_YYYY.csv, DFStats_status_YYYY.csv, DFPlot_YYYY.png, where YYYY is the survey year 		
<i>Optional validation criteria:</i> - none -		
<i>Deliverable ID of any other SEAN data products required to create this product</i> KM_E database rows.		
<i>Description and source of any outside data required to create this product:</i> - none –		

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Form D: Tabular Data Deliverable

<i>Vital Sign:</i> KM Kittlitz’s murrelets	<i>Deliverable ID:</i> KM_J Subpart A	<i>Deliverable Title:</i> Detection Function
<i>File format:</i> Comma-delimited ASCII text	<i>Associated software and version:</i> DISTANCE	<i>Revision Date / protocol version:</i> 10-31-2012 / 2012.1
<i>Expected frequency:</i> 1 submission/year	<i>Likely dissemination partners:</i> None – served by SEAN	<i>Submission unit:</i> Year
<i>What purpose does this deliverable serve?</i> Documents the estimated detection function for a survey year; used to produce the KM_K population estimates for analyses of trend (but not status).		
<i>Identifiers of relations that compose the tabular deliverable (“Relations” are tables or files that provide information which may be represented in a grid format. Each relation listed must be fully defined in its own accompanying Form X.):</i>		
<i>Deliverable ID of any other SEAN data products required to create this product</i> KM_E database rows.		
<i>Description and source of any outside data required to create this product:</i> Program DISTANCE generates the underlying information for the .csv file.		

Form X: Relation Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Relation identifier:</i> DFStats_YYYY.csv	<i>Used by deliverable ID:</i> KM_J/A
<i>Revision date / protocol version:</i> 11-21-2012 / 2012.1	<i>Type of relation:</i> <input type="radio"/> Database table <input checked="" type="radio"/> Data file	<i>Estimated rows:</i> 36/year
<i>Primary key for this relation:</i> - none -		
<i>Purpose</i> Documents the estimated detection function for a survey year; used to produce the KM_K population estimates for analyses of status (but not trend).		
<i>Identifiers of attributes defined over this relation ("Attributes" are columns of the grid. Each attribute must be defined in an accompanying Form Y.):</i> :		
COLUMN_1	COLUMN_2	
COLUMN_4	COLUMN_5	
COLUMN_6	COLUMN_7	
COLUMN_10		
Note: this file is specialized output from program DISTANCE consisting of 10 comma-delimited columns, referred to as COLUMN_1 through COLUMN_10. Only the seven attributes listed above are relevant. The other three may be carried along but are ignored.		
<i>Mandatory validation criteria involving multiple attributes:</i> - none -		
<i>Optional validation criteria involving multiple attributes:</i> - none -		

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> COLUMN_1	<i>Used by deliverable ID:</i> KM_J/A
<i>Revision date / protocol version:</i> 10-31-2012 / 2012.1	<i>Default report heading:</i>	<i>Relation (from Form X):</i> DFStats_YYYY.csv
<i>Purpose:</i> Used to identify the parameter whose value is recorded on this row.		
<i>Data type:</i>	Int	
<i>Maximum length</i>	1	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	9	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must represent a valid integer. 2. Must be between 0 and 3. 	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> COLUMN_2	<i>Used by deliverable ID:</i> KM_J/A
<i>Revision date / protocol version:</i> 11-21-2012 / 2012.1	<i>Default report heading:</i>	<i>Relation (from Form X):</i> DFStats_YYYY.csv
<i>Purpose:</i> Indicates which of the estimates in the file is preferred for use in analyses of population trend. A 'Y' value directs use of the estimate in this row. Any other value is ignored.		
<i>Data type:</i>	Varchar(1)	
<i>Maximum length</i>	1	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	Ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. A 'Y' must be present in one and only one row of the source file for each species 	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> COLUMN_4	<i>Used by deliverable ID:</i> KM_J/A
<i>Revision date / protocol version:</i> 10-31-2012 / 2012.1	<i>Default report heading:</i>	<i>Relation (from Form X):</i> DFStats_YYYY.csv
<i>Purpose:</i> Used to further identify the parameter whose value is recorded on this row.		
<i>Data type:</i>	Int	
<i>Maximum length</i>	1	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	9	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must represent a valid integer. 2. Must be between 1 and 3. 	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> COLUMN_5	<i>Used by deliverable ID:</i> KM_J/A
<i>Revision date / protocol version:</i> 10-31-2012 / 2012.1	<i>Default report heading:</i>	<i>Relation (from Form X):</i> DFStats_YYYY.csv
<i>Purpose:</i> Used to further identify the parameter whose value is recorded on this row.		
<i>Data type:</i>	Int	
<i>Maximum length</i>	3	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	990	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must represent a valid integer. 2. Must be between 1 and 200. 	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> COLUMN_6	<i>Used by deliverable ID:</i> KM_J/A
<i>Revision date / protocol version:</i> 10-31-2012 / 2012.1	<i>Default report heading:</i>	<i>Relation (from Form X):</i> DFStats_YYYY.csv
<i>Purpose:</i> Value of the parameter.		
<i>Data type:</i>	Real	
<i>Maximum length</i>	12	
<i>Required:</i>	yes	
<i>Measurement units:</i>	varies	
<i>Format:</i>	99990.999999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must represent a valid real number. 2. Must be between -20,000.0 and 30,000.0. 	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> COLUMN_7	<i>Used by deliverable ID:</i> KM_J/A
<i>Revision date / protocol version:</i> 10-31-2012 / 2012.1	<i>Default report heading:</i>	<i>Relation (from Form X):</i> DFStats_YYYY.csv
<i>Purpose:</i> Coefficient of variation of the parameter.		
<i>Data type:</i>	Real	
<i>Maximum length</i>	12	
<i>Required:</i>	yes	
<i>Measurement units:</i>	varies	
<i>Format:</i>	990.99999999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must represent a valid real number. 2. Must be between 0.0 and 100.0. 	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> COLUMN_10	<i>Used by deliverable ID:</i> KM_J/A
<i>Revision date / protocol version:</i> 10-31-2012 / 2012.1	<i>Default report heading:</i>	<i>Relation (from Form X):</i> DFStats_YYYY.csv
<i>Purpose:</i> Degrees of freedom of the parameter.		
<i>Data type:</i>	Real	
<i>Maximum length</i>	12	
<i>Required:</i>	yes	
<i>Measurement units:</i>	varies	
<i>Format:</i>	990.99999999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must represent a valid real number. 2. Must be between 0.0 and 4,000.0. 	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form D: Tabular Data Deliverable

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Deliverable ID:</i> KM_J Subpart B	<i>Deliverable Title:</i> Detection Function
<i>File format:</i> Comma-delimited ASCII text	<i>Associated software and version:</i> DISTANCE	<i>Revision Date / protocol version:</i> 10-31-2012 / 2012.1
<i>Expected frequency:</i> 1 submission/year	<i>Likely dissemination partners:</i> None – served by SEAN	<i>Submission unit:</i> Year
<i>What purpose does this deliverable serve?</i> Documents the detection function parameters for a year; used to produce KM_K for analyses of population status (but not trend).		
<i>Identifiers of relations that compose the tabular deliverable ("Relations" are tables or files that provide information which may be represented in a grid format. Each relation listed must be fully defined in its own accompanying Form X.):</i>		
<i>Deliverable ID of any other SEAN data products required to create this product</i> KM_E database rows.		
<i>Description and source of any outside data required to create this product:</i> Program DISTANCE generates the underlying information for the TXT file.		

Form X: Relation Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Relation identifier:</i> DFStats_status_yyyy.csv	<i>Used by deliverable ID:</i> KM_J/B
<i>Revision date / protocol version:</i> 11-21-2012 / 2012.1	<i>Type of relation:</i> <input type="radio"/> Database table <input checked="" type="radio"/> Data file	<i>Estimated rows:</i> 36/year
<i>Primary key for this relation:</i> - none -		
<i>Purpose</i> Documents the detection function parameters for a year; used to produce KM_K for analyses of population status (but not trend).		
<i>Identifiers of attributes defined over this relation ("Attributes" are columns of the grid. Each attribute must be defined in an accompanying Form Y.):</i> :		
COLUMN_1	COLUMN_2	
COLUMN_4	COLUMN_5	
COLUMN_6	COLUMN_7	
COLUMN_10		
Note: this file is specialized output from program DISTANCE consisting of 10 comma-delimited columns, referred to as COLUMN_1 through COLUMN_10. Only the seven attributes listed above are relevant. The other three may be carried along but are ignored.		
<i>Mandatory validation criteria involving multiple attributes:</i> - none -		
<i>Optional validation criteria involving multiple attributes:</i> - none -		

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> COLUMN_1	<i>Used by deliverable ID:</i> KM_J/B
<i>Revision date / protocol version:</i> 10-31-2012 / 2012.1	<i>Default report heading:</i>	<i>Relation (from Form X):</i> DFStats_status_yyyy.csv
<i>Purpose:</i> Used to identify the parameter whose value is recorded on this row.		
<i>Data type:</i>	Int	
<i>Maximum length</i>	1	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	9	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must represent a valid integer. 2. Must be between 0 and 3. 	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> COLUMN_2	<i>Used by deliverable ID:</i> KM_J/B
<i>Revision date / protocol version:</i> 11-21-2012 / 2012.1	<i>Default report heading:</i>	<i>Relation (from Form X):</i> DFStats_status_yyyy.csv
<i>Purpose:</i> Indicates which of the estimates in the file is preferred for use in analyses of population status. A 'Y' value directs use of the estimate in this row. Any other value is ignored		
<i>Data type:</i>	Varchar(1)	
<i>Maximum length</i>	1	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	Ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. A 'Y' must be present in one and only one row of the source file for each species 	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> COLUMN_4	<i>Used by deliverable ID:</i> KM_J/B
<i>Revision date / protocol version:</i> 10-31-2012 / 2012.1	<i>Default report heading:</i>	<i>Relation (from Form X):</i> DFStats_status_yyyy.csv
<i>Purpose:</i> Used to further identify the parameter whose value is recorded on this row.		
<i>Data type:</i>	Int	
<i>Maximum length</i>	1	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	9	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must represent a valid integer. 2. Must be between 1 and 3. 	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> COLUMN_5	<i>Used by deliverable ID:</i> KM_J/B
<i>Revision date / protocol version:</i> 10-31-2012 / 2012.1	<i>Default report heading:</i>	<i>Relation (from Form X):</i> DFStats_status_yyyy.csv
<i>Purpose:</i> Used to further identify the parameter whose value is recorded on this row.		
<i>Data type:</i>	Int	
<i>Maximum length</i>	3	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	990	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must represent a valid integer. 2. Must be between 1 and 200. 	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> COLUMN_6	<i>Used by deliverable ID:</i> KM_J/B
<i>Revision date / protocol version:</i> 10-31-2012 / 2012.1	<i>Default report heading:</i>	<i>Relation (from Form X):</i> DFStats_status_yyyy.csv
<i>Purpose:</i> Value of the parameter.		
<i>Data type:</i>	Real	
<i>Maximum length</i>	12	
<i>Required:</i>	yes	
<i>Measurement units:</i>	varies	
<i>Format:</i>	99990.999999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must represent a valid real number. 2. Must be between -20,000.0 and 30,000.0. 	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> COLUMN_7	<i>Used by deliverable ID:</i> KM_J/B
<i>Revision date / protocol version:</i> 10-31-2012 / 2012.1	<i>Default report heading:</i>	<i>Relation (from Form X):</i> DFStats_status_yyyy.csv
<i>Purpose:</i> Coefficient of variation of the parameter.		
<i>Data type:</i>	Real	
<i>Maximum length</i>	12	
<i>Required:</i>	yes	
<i>Measurement units:</i>	varies	
<i>Format:</i>	990.99999999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must represent a valid real number. 2. Must be between 0.0 and 100.0. 	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> COLUMN_10	<i>Used by deliverable ID:</i> KM_J/B
<i>Revision date / protocol version:</i> 10-31-2012 / 2012.1	<i>Default report heading:</i>	<i>Relation (from Form X):</i> DFStats_status_yyyy.csv
<i>Purpose:</i> Degrees of freedom of the parameter.		
<i>Data type:</i>	Real	
<i>Maximum length</i>	12	
<i>Required:</i>	yes	
<i>Measurement units:</i>	varies	
<i>Format:</i>	990.99999999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	<ol style="list-style-type: none"> 1. Must represent a valid real number. 2. Must be between 0.0 and 4,000.0. 	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form C: Non-Tabular Data Deliverable

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Deliverable ID:</i> KM_J Subpart C	<i>Deliverable Title:</i> Detection function
<i>File format:</i> PNG	<i>Associated software and version:</i> Browsers, etc.	<i>Revision Date / protocol version:</i> 10-31-2012/ KM-2012.1
<i>Expected frequency:</i> 1/year	<i>Likely dissemination partners:</i> None – served by SEAN	<i>Submission unit:</i> Year
<i>What purpose does this deliverable serve?</i> Visualizes the detection function.		
<i>Summary of content:</i> Graphic plot depicting the detection function for the survey year.		
<i>Mandatory validation criteria:</i> <ul style="list-style-type: none"> • Must be a valid PNG file. 		
<i>Optional validation criteria:</i> - none -		
<i>Deliverable ID of any other SEAN data products required to create this product</i> Certified KM_E database.		
<i>Description and source of any outside data required to create this product:</i>		

Deliverable definition forms:

Form D: Tabular Data Deliverable

<i>Vital Sign:</i> KM Kittlitz’s murrelets	<i>Deliverable ID:</i> KM_K	<i>Deliverable Title:</i> Abundance Estimates
<i>File format:</i> n/a	<i>Associated software and version:</i> n/a	<i>Revision Date / protocol version:</i> 10-26-2012 / 2012.1
<i>Expected frequency:</i> 1 submission/year	<i>Likely dissemination partners:</i> None – served by SEAN	<i>Submission unit:</i> YEAR
<i>What purpose does this deliverable serve?</i> Provides annual estimates of abundance and density for murrelet populations.		
<i>Identifiers of relations that compose the tabular deliverable (“Relations” are tables or files that provide information which may be represented in a grid format. Each relation listed must be fully defined in its own accompanying Form X.):</i> tbl_km_observation		
<i>Deliverable ID of any other SEAN data products required to create this product:</i> KM_E KM_J		
<i>Description and source of any outside data required to create this product:</i> Probability of detection at transect center line, currently supplied as a static value based on a 2009 study and stored in km.tbl_detection_centerline.		

Form X: Relation Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Relation identifier:</i> tbl_abundance_estimates	<i>Used by deliverable ID:</i> KM_K
<i>Revision date / protocol version:</i> 10-26-2012 / 2012.1	<i>Type of relation:</i> Database Table	<i>Estimated rows:</i> 20/year
<i>Primary key for this relation:</i> Survey_year+analysis_code+species_code +attribute_code		
<i>Purpose:</i> Holds output from R program execution that gives murrelet population abundance and density, along with supporting statistical measures.		
<i>Identifiers of attributes defined over this relation ("Attributes" are columns of the grid. Each attribute must be defined in an accompanying Form Y.):</i>		
SURVEY_YEAR	ANALYSIS_CODE	
SPECIES_CODE	ATTRIBUTE_CODE	
ESTIMATE	SE	
VAR	N	
DF	CL_LOWER_95_PCT	
CL_UPPER_95_PCT	COMMENTS	
TIME_STAMP	USERID	
PROTOCOL_ID	SUBMISSION_NUMBER	
<i>Mandatory validation criteria involving multiple attributes:</i> - none -		
<i>Optional validation criteria involving multiple attributes:</i> - none -		

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> SURVEY_YEAR	<i>Used by deliverable ID:</i> KM_K
<i>Revision date / protocol version:</i> 10-26-2012 / 2012.1	<i>Default report heading:</i> Year	<i>Relation (from Form X):</i> tbl_abundance_estimates
<i>Purpose:</i> They 4-digit year for which the estimates are made.		
<i>Data type:</i>	Integer	
<i>Maximum length</i>	4	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	9999	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must be >= 2009. 2. Must be <= year of validation	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> ANALYSIS_CODE	<i>Used by deliverable ID:</i> KM_K
<i>Revision date / protocol version:</i> 10-26-2012 / 2012.1	<i>Default report heading:</i> Analysis	<i>Relation (from Form X):</i> tbl_abundance_estimates
<i>Purpose:</i> Whether the values apply to estimates for analyses of population status or trend:		
<i>Data type:</i>	Varchar(6)	
<i>Maximum length</i>	6	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must be 'STATUS' or 'TREND'.	
<i>Optional validation rules for this attribute:</i>	- none -	

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Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> SPECIES_CODE	<i>Used by deliverable ID:</i> KM_K
<i>Revision date / protocol version:</i> 10-26-2012 / 2012.1	<i>Default report heading:</i> Species	<i>Relation (from Form X):</i> tbl_abundance_estimates
<i>Purpose:</i> Species to which the estimates apply:		
<i>Data type:</i>	Varchar(14)	
<i>Maximum length</i>	14	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must be 'BRACHYRAMPHUS', 'KITTLITZS', 'MARBLED' OR 'UNKNOWN'.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> ATTRIBUTE_CODE	<i>Used by deliverable ID:</i> KM_K
<i>Revision date / protocol version:</i> 10-26-2012 / 2012.1	<i>Default report heading:</i> Type	<i>Relation (from Form X):</i> tbl_abundance_estimates
<i>Purpose:</i> The particular component the estimate applies to.		
<i>Data type:</i>	Varchar(24)	
<i>Maximum length</i>	24	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must be 'ABUNDANCE', 'ADJUSTED.ENCOUNTER.RATE', 'DENSITY' or 'ENCOUNTER.RATE'	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> ESTIMATE	<i>Used by deliverable ID:</i> KM_K
<i>Revision date / protocol version:</i> 10-26-2012 / 2012.1	<i>Default report heading:</i> Estimate	<i>Relation (from Form X):</i> tbl_abundance_estimates
<i>Purpose:</i> The value of the parameter being estimated.		
<i>Data type:</i>	real	
<i>Maximum length</i>	12	
<i>Required:</i>	no	
<i>Measurement units:</i>	See "ATTRIBUTE_CODE" above	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must be ≥ 0 .	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> SE	<i>Used by deliverable ID:</i> KM_K
<i>Revision date / protocol version:</i> 10-26-2012 / 2012.1	<i>Default report heading:</i> Std Error	<i>Relation (from Form X):</i> tbl_abundance_estimates
<i>Purpose:</i> The SE of the parameter estimate.		
<i>Data type:</i>	real	
<i>Maximum length</i>	12	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must be ≥ 0 .	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> VAR	<i>Used by deliverable ID:</i> KM_K
<i>Revision date / protocol version:</i> 10-26-2012 / 2012.1	<i>Default report heading:</i> Variance	<i>Relation (from Form X):</i> tbl_abundance_estimates
<i>Purpose:</i> Variance of the parameter estimate.		
<i>Data type:</i>	real	
<i>Maximum length</i>	12	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must be ≥ 0 .	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> N	<i>Used by deliverable ID:</i> KM_K
<i>Revision date / protocol version:</i> 10-26-2012 / 2012.1	<i>Default report heading:</i> n	<i>Relation (from Form X):</i> tbl_abundance_estimates
<i>Purpose:</i> Sample size for the estimate.		
<i>Data type:</i>	real	
<i>Maximum length</i>	12	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must be ≥ 0 .	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> DF	<i>Used by deliverable ID:</i> KM_K
<i>Revision date / protocol version:</i> 10-26-2012 / 2012.1	<i>Default report heading:</i> Degrees of freedom	<i>Relation (from Form X):</i> tbl_abundance_estimates
<i>Purpose:</i> Degrees of freedom for the estimate.		
<i>Data type:</i>	real	
<i>Maximum length</i>	12	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must be ≥ 0 .	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> CL_LOWER_95_PCT	<i>Used by deliverable ID:</i> KM_K
<i>Revision date / protocol version:</i> 10-26-2012 / 2012.1	<i>Default report heading:</i> Lower 95% confidence	<i>Relation (from Form X):</i> tbl_abundance_estimates
<i>Purpose:</i> The lower 95% confidence limit value.		
<i>Data type:</i>	real	
<i>Maximum length</i>	12	
<i>Required:</i>	no	
<i>Measurement units:</i>	Same as ESTIMATE.	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must be a real number.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> CL_UPPER_95_PCT	<i>Used by deliverable ID:</i> KM_K
<i>Revision date / protocol version:</i> 10-26-2012 / 2012.1	<i>Default report heading:</i> Upper 95% confidence	<i>Relation (from Form X):</i> tbl_abundance_estimates
<i>Purpose:</i> The lower 95% confidence limit value.		
<i>Data type:</i>	real	
<i>Maximum length</i>	12	
<i>Required:</i>	no	
<i>Measurement units:</i>	Same as ESTIMATE.	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must be ≥ 0 .	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> COMMENTS	<i>Used by deliverable ID:</i> KM_K
<i>Revision date / protocol version:</i> 10-26-2012 / 2012.1	<i>Default report heading:</i> Comments	<i>Relation (from Form X):</i> tbl_abundance_estimates
<i>Purpose:</i> Freeform text describing exceptions.		
<i>Data type:</i>	Varchar(1024)	
<i>Maximum length</i>	1024	
<i>Required:</i>	no	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> TIME_STAMP	<i>Used by deliverable ID:</i> KM_K
<i>Revision date / protocol version:</i> 10-26-2012 / 2012.1	<i>Default report heading:</i> Last Updated	<i>Relation (from Form X):</i> tbl_abundance_estimates
<i>Purpose:</i> The date and time this row was most recently inserted or updated in the table. It is used for auditing purposes.		
<i>Data type:</i>	datetime	
<i>Maximum length</i>	n/a	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	n/a	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	- none -	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> USERID	<i>Used by deliverable ID:</i> KM_K
<i>Revision date / protocol version:</i> 10-26-2012 / 2012.1	<i>Default report heading:</i> Updated by	<i>Relation (from Form X):</i> tbl_abundance_estimates
<i>Purpose:</i> The login name used to authorize the process that created/updated this row in the cumulative database. It is restricted to those userids stored in the database table called tbl_submitter. It is used for auditing purposes.		
<i>Data type:</i>	Varchar(20)	
<i>Maximum length</i>	20	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	sean.tbl_submitter.submitter_userid	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must match a userid in tbl_submitter.	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> PROTOCOL_ID	<i>Used by deliverable ID:</i> KM_K
<i>Revision date / protocol version:</i> 10-26-2012 / 2012.1	<i>Default report heading:</i> Protocol	<i>Relation (from Form X):</i> tbl_abundance_estimates
<i>Purpose:</i> The formal version identifier of the monitoring protocol document that was observed during the collection of these data. For example, "KM-2012.1".		
<i>Data type:</i>	Varchar(10)	
<i>Maximum length</i>	10	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	sean.tbl_protocol.protocol	
<i>Case:</i>	ignored	
<i>Mandatory validation rules for this attribute (in order of application):</i>	1. Must match a protocol in sean.tbl_protocol	
<i>Optional validation rules for this attribute:</i>	- none -	

Form Y: Attribute Definition

<i>Vital Sign:</i> KM Kittlitz's murrelets	<i>Attribute identifier:</i> SUBMISSION_NUMBER	<i>Used by deliverable ID:</i> KM_K
<i>Revision date / protocol version:</i> 10-26-2012 / 2012.1	<i>Default report heading:</i> Submission#	<i>Relation (from Form X):</i> tbl_abundance_estimates
<i>Purpose:</i> The submission number used to transmit to the network the files from which this particular row came. It is used for several data management purposes, including auditing.		
<i>Data type:</i>	int	
<i>Maximum length</i>	n/a	
<i>Required:</i>	yes	
<i>Measurement units:</i>	n/a	
<i>Format:</i>	n/a	
<i>Foreign key to (relation+attribute):</i>	km.tbl_submission_log.submission_number	
<i>Case:</i>	n/a	
<i>Mandatory validation rules for this attribute (in order of application):</i>	2. Must match a submission_number in km.tbl_submission_log.	
<i>Optional validation rules for this attribute:</i>	- none -	

SOP 1: At-Sea Surveys

Version 1.0

Revision History Log:

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

Summary

At-sea line transect surveys are conducted to collect data for estimating species-specific on-water density, abundance, and spatial distribution of murrelets. The Boat Pilot, Observers, and Data Recorder work as a team to occupy transects, record observations, and ensure data security during field operations. This SOP details the equipment necessary to successfully perform the surveys, specific duties for each team member, and research vessel management.

Personnel, Platform, and Equipment

Boat-based line transect surveys are performed annually during early July with a minimum standard crew size of four, including the Boat Pilot, Data Recorder, and two Observers. Although suboptimal, one Observer may be used when necessary. SOP 9 discusses details of office and field training for Observers. The GLBA Ecologist assists with park logistics leading up to surveys and processes the park research permit. No other permits are necessary, but each year the Ecologist should check whether special one-time exemptions are required, such as entering John Hopkins Inlet for occupying permanent transects when a motorized vessel closure due to seal pupping has been extended into the survey period. GLBA Visitor Information Services (VIS) manages float plans for the at-sea survey crew each day.

Surveys should be conducted from boats 8 to 10 m long that provide an open bow platform with room for at least two Observers, a viewing height of approximately 2.5 m above water, a covered cabin with suitable space and power supply for data recording equipment, and the capability to maintain a relatively constant bearing at approximately 10 km/h. The *R/V Fog Lark*, an 8.5 m long Munson landing craft with large front deck, is currently the primary survey vessel because of its large covered cabin, bow deck, and twin outboard motor configuration (which improves straight-line transect tracking). The *R/V Capelin* is the first alternate vessel.

Packing the appropriate and properly functioning equipment and supplies (Table SOP 1.1) should begin by early June to allow time to replace or repair equipment. Permitting logistics may need to be started much earlier and may vary annually based on transects in the current year’s survey panel. The Project Leader and relevant GLBA staff should communicate to determine an appropriate schedule for permitting.

Table SOP 1.1. Packing checklist for at-sea surveys.

-
- 60 blank Observer data forms
 - 30 blank Distance Calibration – Observer and Session Sergeant data forms
 - Pencils
 - Clipboard
 - Notebook
 - Hardcopy of protocol package

 - GPS with transect waypoints loaded
 - Backup GPS with transect waypoints
 - 12vdc GPS cord
 - Serial GPS cord
 - External antenna
 - Spare AA batteries
 - Hardcopy coordinates of transect endpoints
 - Hardcopy map of the year's closed areas
 - Hardcopy of relevant permits
 - 2 laminated hardcopy maps of the year's transects

 - Tested laptop with ArcMobile, ArcMap, stand-alone license, and NPTransect application configured for the current year
 - Backup laptop
 - 2 32GB thumb drives
 - 2 power bricks
 - Port replicator
 - USB/serial converter and driver
 - Hardcopy NPTransect documentation

 - 2 laser rangefinders
 - 2 spare CR2 batteries
 - 3 binoculars (or more)
 - Anti-fog wipes
 - 4 park radios
 - Park radio charger
 - Spare radio batteries

 - Tripod
 - Angle board with appropriate tripod mounting hardware
 - 6 to 10 calibration buoys
 - Extra infrared retro-reflective tape
 - Dip net

 - Personal flotation devices
 - Boat safety/survival gear
 - Boat GPS with transect waypoints loaded
 - SEAN-provided sleeping bags and pads
 - Cooler / ice
-

Preparing the Data Acquisition Facility

Before commencing field work, the Data Recorder or other qualified staff ensures that the main handheld, backup, and boat-mounted GPS units are properly configured and that the NPTransect application is installed and tested on appropriate laptop computers.

1. Prepare NPTransect application before fieldwork commences

- a. If needed, operating and troubleshooting procedures are detailed in Appendix F: NPTransect-KIMU Operating Manual.
- b. Prepare an NPTransect package to be used for installing the application on laptops.
 - i. The Data Manager must coordinate with AKRO GIS support well before each field season to determine if the latest NPTransect package needs to be revised to meet current requirements.
 - ii. If updates are needed, they should be built into a complete NPTransect package in order to fit with the standard installation steps listed below.
 1. The package should be developed based in the prior version package which includes application, ESRI system software, required features classes (*e.g.*, TRANSECT), imagery, file geodatabase structure, and other items.
 2. The final package should be stored for use at \\inpglbafs03\data\SEAN_Data\Work_Zone\KM\yyyy\NPTransect\KIMU_yy_yy_starting_copy, where 'yyyy' is the calendar year of the survey.
 - iii. If software updates are not required, then just copy the prior end of season NPTransect package into \\inpglbafs03\data\SEAN_Data\Work_Zone\KM\yyyy\NPTransect\KIMU_yyyy_starting_copy, where 'yyyy' is the calendar year of the survey.
- c. Adjust package to work in the current year
 - i. Enable transect panel for current year
 1. Open \\inpglbafs03\data\SEAN_Data\Work_Zone\KM\yyyy\NPTransect\KIMU_yy_yy_starting_copy\Murrelets.mxd using ArcMap.
 2. Right click the Transects feature class and select "Properties" from the menu.
 3. Select the "Definition Query" tab and edit the query.
 - a. It must contain the string <"Sample"=0 OR "Sample"=4> in order to recognize the fixed and alternate transects.
 - b. It should also contain either < OR "Sample"=1> to recognize the 2010-based panel, or < OR "Sample"=2> for 2011, or < OR "Sample"=3> for 2012.
 4. Edit the exact same definition into the Murrelets (sync).mxd file. If the definitions do not match in the 2 MXD files, data may be permanently lost.
- d. Clear any data from prior years out of the package
 - i. While the geodatabase is capable of holding multiple years of data, we deliberately start each season with empty observations so the displays are not cluttered with extraneous data during collection and editing.
 - ii. Use Windows Explorer to copy ...\Murrelets_Empty.gdb to ...\Murrelets.gdb
 - iii. Use Windows Explorer to delete any files left in the \BACKUP folder.
 - iv. Use Windows Explorer to delete any files left in the \CSV folder.

2. Install and test NPTransect on laptops before going to the field

- a. The full installation must be performed twice: once for the primary laptop and once for the backup.

- b. Minimum laptop requirements
 - i. Windows 7
 - ii. DB-9 serial port via port replicator and/or reliable USB converter
 - iii. ESRI ArcMap version that is compatible with current NPTransect application
 - iv. ESRI ArcMobile version that is compatible with current NPTransect application
 - v. ESRI stand-alone licenses (which are valid when disconnected from network)
- c. ESRI software installation
 - i. ArcMap
 - 1. Follow latest instructions from AKRO GIS group, most recently at http://inpakroms03web/rgr/akgis/documents/GIS%20Help%20Desk/Cheat%20Sheets/Installing_ArcGIS_10.pdf.
 - ii. ArcMobile
 - 1. The ArcMobile version successfully tested with the application is contained in the NPTransect package. Copy \\inpglbafs03\data\SEAN_Data\Work_Zone\KM\yyyy\NPTransect\KIMU_yy_yy_starting_copy (where 'yyyy' is the calendar year of the survey) to the laptop's C:\KIMU directory – replacing any existing content.
 - 2. Log into the destination laptop as an administrator. The laptop must be connected to the NPS network.
 - 3. From C:\KIMU\ArcMobileDVD, execute the ESRI.exe installer program.
 - 4. Select the option for Arc Mobile (not Arc Mobile Windows Application) and run the installation package.
 - iii. ESRI stand-alone license
 - 1. Follow latest instructions from AKRO GIS group, most recently at http://inpakroms03web/rgr/akgis/documents/GIS%20Help%20Desk/Cheat%20Sheets/Installing_ArcGIS_10.pdf.
 - 2. "Borrowing" licenses is currently detailed in section 8 of the instructions.
 - 3. Verify the stand-alone license works by disconnecting the network cable from the laptop and starting up ArcMap. Contact AKRO GIS support if there's a problem.
- d. NPTransect application installation
 - i. If not already done in the process of installing ArcMobile, copy \\inpglbafs03\data\SEAN_Data\Work_Zone\KM\yyyy\NPTransect\KIMU_yyyy_starting_copy (where 'yyyy' is the calendar year of the survey) to the laptop's C:\KIMU directory.
 - ii. Run C:\KIMU\Scripts\1)InstallOrUpdateMachine.bat as an administrator (right click the file and select Run As Administrator). Verify it reports no errors and dismiss the window.
 - iii. Run C:\KIMU\Scripts\2)InstallOrUpdateUser.bat while logged in as the data recorder user (**not** as administrator).
 - iv. Run C:\KIMU\Scripts\3)SyncUser.bat under the data recorder userid.
 - v. Make a shortcut or quick launch icon for the application, most recently called C:\program files (x86)\ArcGIS\Mobile10.0\bin\ArcGisMobile.exe.

- vi. Test that the application comes up when the shortcut is invoked. Be aware it is normal to see error messages when no GPS is connected.

3. Configure GPS for the season

- a. Data recorder and backup data recorder portable GPS units
 - i. Replace existing AA batteries with fresh ones to assure continuity during field operations.
 - ii. Configuration of GPS
 1. Use the Setup / Interface function
 - a. Serial data format "NMEA In / NMEA Out"
 - b. Baud rate "4800"
 2. Use the Setup / Heading function
 - a. Set North Reference to TRUE
 3. Use the Setup / Units function
 - a. Set Map Datum to WGS84
 - iii. Replace transect waypoints with copies generated from the prior year's file geodatabase feature class named "Transect".
 1. A combination of ArcMap, XTools, Excel, and DNRGarmin may be needed to accomplish this.
 2. The waypoints marked in the field will constitute the year's KM_I deliverable.
 - iv. Boat GPS
 1. A hardcopy listing of transect endpoint coordinates is used to hand enter navigation waypoints for the season.

4. Run an end to end test before operations start

- a. The data collection application and equipment are complex, a number of things can go wrong, and, due to its extensive reliance on location information, the application can only be fully tested within the physical bounds of the park.
- b. A test transect should be executed on initial arrival to Glacier Bay and in advance of any real data capture.
 - i. A test transect must not coincide with a real transect being covered that season. A transect ID "TST" has been established for this purpose.
 1. Actual testing may take place anywhere in the park and does not require being near the actual TST transect.
 2. Test data should not be collected in the physical vicinity of a real transect: test data icons could obscure real data points on the NPTransect screen.
 - ii. The test should consist of interconnecting all equipment, activating the application, entering several dummy observations, saving the work, refreshing the cache, generating the CSV, and creating the backup ZIP.
- c. Any fault must be remedied before field work commences, as the raw data collection process may not be accurately recording observations.

Line Transect Procedures

For each transect, the Observers and Data Recorder collect information on existing environmental conditions (weather and Beaufort sea state), actual observed transect start and end points, and location of murrelet groups relative to the boat. While on transect, the crew should generally use parknet digital radios on a project channel using low power.

Boat Pilot methods

Before beginning each transect, the Boat Pilot confirms identity and location of the selected transect with the Data Recorder. The Boat Pilot uses the onboard GPS/chart plotter to approach the preferred transect start point. Direction of travel along the transect can be selected to minimize travel time or based on considerations such as ease of approach, wind, currents, hazards, etc. The approach path and speed should minimize disturbance to murrelets near the transect prior to commencing sampling.

Approximately 500 m before the transect start point, the Boat Pilot slows down to no wake speed and assists Observers in determining whether murrelets are leaving the area near the transect center line (see 'Observer Methods' below for additional details). At 200 m from the transect start point, the Boat Pilot begins counting down the distance in 50 m increments to the Observers. The Boat Pilot then indicates the start of data recording when the boat reaches the start point and is on the correct bearing. When approaching within 200 m of the start point, Observers should be prepared to survey according to methods outlined in 'Observer Methods' below.

Transects typically run from shoreline-to-shoreline. When starting at the shoreline, the approach should be slow and as close to the shoreline as practical, with a decisive turn onto the transect line. The best approach will depend on conditions, such as wind, currents, and tidal stage. If current is strong, the boat may need to begin turning into the transect 20 or 30 m before the start point. Slow approach speeds (<5 km/hr) help ensure accurate positioning. If the transect start point is in open water, the Boat Pilot may approach the start point along the same bearing as the transect. Upon crossing the transect start point at the correct bearing, the Boat Pilot should indicate commencement of data collection.

Speed on transect should generally be 10 km/hr but may be reduced to as low as ~5 km/hr when high densities of observations occur or to preserve data collection quality (e.g., computer interruption, etc.). Depending on current, ferrying the bow in an up-current direction may help maintain the desired bearing. Zooming in to a small scale on the GPS/chart plotter and using a bearing line function will aid navigation. Maintaining as consistent a bearing and heading as possible will benefit Observers; corrections to steering should be gradual rather than sharp. On zigzag transects, the Boat Pilot should notify observers when approaching (e.g., ~50 m), beginning, and ending the turn.

If the transect ends in open water, at ~500 m the Boat Pilot begins counting down distances to the end point in ~100 m increments. For transects ending at shoreline, the Boat Pilot ends the transect as shallow as practical. Typically, end points occur once water depth is less than ~10 m, but this rule of thumb is dependent on shoreline configuration and bathymetry. Pay close attention to sills and points that may become shallow far from shore. In poor visibility, end points should be conservatively determined to avoid any potential underwater obstructions. Upon reaching an end point, cut the throttle and wait for Observers to complete observations. When Observers declare completion the Data Recorder makes any immediate

required corrections while at the transect endpoint. Once the Data Recorder announces completion, slowly maneuver off shore.

When navigating around small obstructions on-transect (e.g., ice), prefer long, gradual turns minimizing deviation from the transect bearing to shorter, sharper turns. When encountering larger obstructions (e.g., islands), cease sampling at the obstruction, navigate around the obstruction, and resume sampling beyond the obstruction using standard methods for starting transects.

Observer Methods (Note: Observer training procedures are detailed in SOP 9.)

Observers should detect groups initially located on or flushing from the water along the transect, estimate distance and angle to the group, count group size, and transmit records to the Data Recorder. Groups are associations of same-species murrelets separated by $< \sim 5$ m.

Data collection should strive to meet critical assumptions of distance sampling methods: 1) all groups are detected near (i.e., within ~ 50 m) the transect center line (hereafter "center line"), 2) groups are recorded at initial locations, 3) distances from the center line are accurately estimated, and 4) species are correctly identified. Estimation methods account for minor violation of assumption 1 (see Appendix A).

As the Boat Pilot slows when within ~ 500 m of the transect start point, Observers should don PFDs, collect binoculars and radios, occupy the forward deck, set up the angle board, and check radio transmission. While approaching the transect and prior to start of normal data collection (below), Observers should note groups flushing from ± 50 m from the center line. These groups should be recorded upon commencing data collection. Because angle likely cannot be accurately estimated, Observers should estimate perpendicular distance of the group from the transect center line and use the 90° (left/port side of boat) and 270° (right/starboard side of boat) observation angles for these records.

The Boat Pilot will indicate the start of data collection after the boat reaches the transect start point and appropriate bearing. Observers may scan for groups using the naked eye and binoculars. Observed groups are recorded within a strip extending 200 m from the center line, with the surveyed strip extending to the shore for transects intersecting land or, in open water, to a line perpendicular to the transect extending 200 m from the transect end point. Observations typically are recorded for groups ≤ 200 m forward of the boat, with exceptions for observations ≤ 300 m for groups that 1) are moving rapidly away from the center line (to fix groups at their initial location), 2) flush from the water within ~ 50 m of the center line (to meet assumption of complete detection near the center line), or 3) lie within the surveyed area but are unlikely to be recorded later (e.g., because of large numbers of concurrent groups).

With two Observers, each should be primarily responsible for scanning waters to one side of the boat. To maximize detection near the center line, both Observers should scan near the center line (i.e., $\pm 30^\circ$ around boat heading), with each giving gradually decreasing attention to waters further from the center line. To facilitate angle estimation (below), it may be convenient for each Observer to focus on the side of the boat opposite their deck location.

However, Observers may record observations from either side of the boat and should frequently communicate to optimize data collection. In particular, Observers should communicate to ensure all groups near the center line are recorded once. With only one Observer, attention should be focused along the center

line, with gradually decreasing attention to waters further from the center line on both sides of the boat. Binoculars can increase detection of inconspicuous groups, but the reduced field of vision can result in missing groups that would otherwise be detected. Two Observers judiciously alternating between scanning with binoculars and the naked eye may increase detections without compromising detection near the center line.

For each group detected in the survey area, Observers should estimate angle relative to the boat heading (0-359° using angle board, 180° is dead ahead) and distance from the boat (ocular estimate to nearest 10 m) to group's initial location. Angles <10° from the center line (171-189°) should be estimated to nearest 1°, with others to the nearest 5°. Observers should also count group size and classify each individual to 1 of 3 species classes: K (Kittlitz's murrelet), M (marbled murrelet) or, U (unidentified *Brachyramphus* murrelet). Because there is much greater risk of bias in population estimates associated with misidentified relative to unidentified murrelets, Observers should classify groups to species only when confidence in identification is high (>80%). See SOP 9 for identifying characteristics of each species.

Observers transmit observations to the Data Recorder via hand-held radios using standardized order and codes (Table SOP 1.2). Each transmission begins with the word "record", followed by angle, distance, group size, and species class. Observers may correct prior records. When making corrections, Observers should give pertinent information to help the Data Recorder identify the record along with the corrected data. If species identity is uncertain, Observers may transmit other information and indicate species class as "pending." Species class will be updated if subsequently provided, but otherwise is recorded as U (unidentified). In cases where >1 groups share the same location (i.e., different species classes associated by < ~5 m), the transmission may include a group size and species class for each group (e.g., "Record, nine zero degrees, five zero meters, 2 M and 2 U").

Where a zigzag transect approaches/departs a waypoint along shore, there will be overlap in the surveyed area on the approach and departure legs. One Observer should continuously monitor groups before and after a turn to avoid double-counting groups. Observers should attempt to estimate distance/angle to each group should when initially located, with the stipulation that these data should not be estimated while the boat is turning.

When encountering high densities of groups, Observers may ask the Boat Pilot to reduce survey speed (\leq ~5 km/hr) to maximize time to record groups. If groups are encountered faster than they can be recorded, Observers should prioritize recording groups nearer to the center line and counting group sizes over species identification. When encountering large numbers of individuals, it may be necessary to lump loosely aggregated individuals of the same species class into a single "group" in order to ensure individuals are recorded in a timely manner.

Table SOP 1.2. Data transmission order and codes for each data category. The order of reporting to the Data Recorder is as follows: "Record," angle, distance, group size, species class (e.g., "Record, one-three-zero degrees, nine-zero meters, 2, K")

Reporting Category	Category Unit or Choice	Definitions
Angle	Degrees	Angle relative to heading of boat (180°)
Distance	Meters	Distance from Observer to group
Group size	Number	Count of individuals
Species class	K	Kittlitz's murrelet
	M	Marbled murrelet
	U	Unidentified <i>Brachyramphus</i> murrelet

Data Recorder Methods

The Data Recorder is responsible for multiple duties at once, including entering observations into NPTransect, communicating with Observers over park radio, and communicating with the Boat Pilot regarding transect locations and straight-line tracking. Due to the large number of tasks, Data Recorder methods below are presented in numbered list form to obviously delineate each set of tasks throughout a sampling day.

At the start of each day, before occupying any transects, the Data Recorder ensures the following items are completed:

1. Be certain the portable GPS is either turned off or disconnected from the laptop.
2. Power up laptop and log in with the userid NPTransect has been set up in.
3. Turn on the GPS and plug serial cable into the laptop if not already connected.
4. Check that GPS and laptop are running off of boat power; if not, either could fail on the transect.
 - a. Synchronize cache to be certain the cache matches the cumulative geodatabase.
 - i. Start up Windows Explorer (not Internet Explorer!)
 - ii. Navigate to the folder C:\KIMU\SCRIPTS
 - iii. Double click on the entry labeled "3)SyncUser.bat"
 - iv. The program may take several minutes to complete
 - v. If an error message appears, stop and take corrective action. Any error indicates the laptop is not in a position to correctly record observations.
 - vi. Dismiss the script's black command window by clicking on it and pressing any key
 - b. Prepare paper field observer form with header information
 - c. Start application
 - i. Verify GPS has acquired satellites – application will not work until the GPS is ready.
 - ii. If not already running, start NPTransect with the quick-start icon or under All Programs / ArcGIS/ ArcGIS Mobile/ ArcGIS Mobile.
 - iii. If the application complains it can't find the GPS, force a retry
 1. Click the upper right icon that looks like a satellite
 2. Click the menu item GPS Status
 3. Fill the Serial Port dropdown with AUTO
 4. Set the Baud Rate to 4800
 5. Press the green connect button

6. Once the GPS is reporting, click the white BACK button to show the GIS screen
 - iv. Verify the imagery reflects the approximate location of the boat.

While approaching the beginning of a transect, the Data Recorder ensures the following items are completed:

1. At about 200 meters from the transect start, press NPTransect's green TASKS button and select from the menu "Collect Information"
2. Data entry fields will appear for defining the initial header information.
3. Note that the Transect dropdown only reflects transects visible on the screen. Press the BACK button and zoom out if necessary to bring the target transect into the range of the screen.
4. Leave the ON TRANSECT box unchecked
5. At about 100 meters, press the green START RECORDING button. At this point trackpoints get written to the file geodatabase at the rate of 30 per minute.
6. Notify the Observers that recording has begun.

While on transect, the Data Recorder performs the following:

1. Mark the ON TRANSECT check box when this is announced by the Boat Captain.
2. Write the start time on the field data sheet.
3. As conditions change revise visibility, weather, and Beaufort.
 - a. Use the combo boxes and check boxes near the top of the screen.
 - b. These are only visible when no observations are outstanding.
 - c. Also write the change on the field data form.
4. If other header data, such as observer name, needs correction while on transect:
 - a. Be certain no observations are outstanding; incomplete observations will be lost.
 - b. Press the ESC key to display the header data field screen.
 - c. Revise the field(s).
 - d. Press the green START RECORDING button to resume.
 - e. Be aware that no tracklog data are captured while the header fields are being revised, so do this quickly.
5. Whenever the transect is interrupted and resumed, record the fact by toggling the ON TRANSECT check box; note observations cannot be entered unless ON TRANSECT is checked.
6. When an observation is radioed in:
 - a. Open new record by pressing the green NEW OBSERVATION button, typing CTRL-N, or hitting the enter key.
 - b. Record Angle, Distance, Group Size.
 - c. If species class is included:
 - i. Record it and close out the record by pressing the green SAVE button (or keyboard shortcut CTRL-S).
 - ii. Acknowledge record by keying microphone.
 - d. If species class is not immediately known:
 - i. Then leave record open.

- ii. Enter/acknowledge species class when it is later radioed in and save the record.
 - iii. If an intervening observation comes in, use CTRL-N to record it while leaving the incomplete prior record in the background for subsequent completion. Multiple records may be open simultaneously, though the recorder must keep track of which records correspond to which observations of particular observers.
 - iv. If multiple open records become too complex to track, enter tab id of one or more open records on field sheet and save those incomplete open records; write eventual species and other corrections on paper form in appropriate row. These will be applied at a later stage.
- e. If Observers report corrections after record is saved, record them on field sheet using record key timestamp obtained by clicking on its observation icon. Do not attempt to edit existing observations while on transect as new observations may be lost while involved in the cumbersome editing process.
- f. If an observation must be deleted, it may be done while on transect as deletion is much quicker than editing.
 - i. Click the screen icon of the observation.
 - ii. A message box appears with three buttons: click on the one marked DELETE.
- g. In the event the application fails during a transect
 - i. Record a waypoint for each incoming observation using the attached GPS, taking the default sequential numeric ID assigned to each waypoint by the GPS.
 - ii. Mark each waypoint number and observation details on a row of the field sheet.
 - iii. Complete the transect using this manual process.
- h. In the event the GPS fails during a transect
 - i. Uncheck ON TRANSECT.
 - ii. Notify the team recording has paused.
 - iii. Request boat operator holds position.
 - iv. Immediately swap in the backup device.
 - v. If the backup starts recording trackpoints properly, check ON TRANSECT and notify team of resumption.
 - vi. If the backup cannot be made operational, notify team that the transect must be aborted.
- i. When Observers call end of transect:
 - i. Uncheck ON TRANSECT but do NOT stop recording.
 - ii. Write the stop time on the field data sheet.

After completing a transect, the Data Recorder does the following:

1. Perform any outstanding edits listed on the field log sheet:
 - a. Click on the observation's icon based on record key time.
 - b. When the message box appears, click the edit button.
 - c. Be certain the timestamp matches the record key on the form; it may take several attempts to find the correct one.
 - d. Make the edits and resave.
 - e. Check off the item from the field log sheet.
 - i. Click the red STOP RECORDING button. Once stopped, it is not possible to further edit/delete observations on the transect.
 - ii. Be aware the application does not support creating new observations manually. New observations have to be applied to the KM_D corrected observations deliverable at the end of the field effort.

End-of-day Field Data Management

Since KIMU survey data requires long days during short seasonal time windows, it is important that each day's data is properly backed up and reviewed each day, as feasible.

1. In the event automated recording failed during the day and manual recording was performed:
 - a. Remedy any equipment or software problems so there will be backup facilities for the next survey day.
 - b. Have data recorder take any necessary actions to ensure data on the two machines used during the day are both merged into the geodatabase without any loss.
2. Synchronize cache information collected that day to the cumulative geodatabase.
 - a. Start up Windows Explorer (not Internet Explorer!)
 - b. Navigate to the folder C:\KIMU\SCRIPTS
 - c. Double click on the entry labeled "3)SyncUser.bat"
 - d. The program may take several minutes to complete
 - e. If an error message appears, stop and take corrective action. Any error indicates the laptop is not in a position to record further observations.
 - f. Dismiss the script's black window by clicking on it and pressing any key
3. Generate a fresh CSV file for the current year.
 - a. From Windows Explorer, double-click 4)ExportToCSV.bat
 - b. Any errors should be diagnosed and repaired. An error at this point, however, does not necessarily mean the laptop is no longer usable.
 - c. Dismiss the script's window.

4. Review appearance of CSVs for gross errors, optionally using Excel to aid by its sorting and searching.
 - a. If Excel is used, DO NOT SAVE the file because it will no longer meet the CSV format specification required by ESRI.
 - b. Diagnose the nature of any errors and determine corrective action.
 - c. If any subsequent corrections are edited in using the application, the synchronization and CSV generation processes will have to be repeated.
5. Create a backup file containing all original data by executing 5)SnapshotToZip.bat.
6. Back up the C:\KIMU folder and its subsidiary contents to a thumb drive under a folder named for the current date (e.g., "KIMU_2011-07-15").
7. If the evening is spent on land, store all completed field sheets in a secure location – do not return them to the boat where they may be lost or damaged. Also, leave the latest thumb drive on land and take the second drive into the field for the same reasons.

Vessel Management

Good vessel management is essential for completing KIMU surveys safely and efficiently. This section specifically discusses management of the *R/V Fog Lark*, the primary survey vessel.

Before the surveys begin, a general overview float plan should be prepared in a Word document and provided to the VIS, GLBA Ecologist, and relevant protection rangers. This will give park staff a general idea of when float plans will be filed, day-to-day locations of the *Fog Lark*, and days when non-motorized or critical habitat exemptions will be activated. Before each survey, check with the VIS for the most current float plan protocols.

Each survey morning, the Boat Pilot activates a float plan with the VIS that includes information on time of departure, number of crew onboard (including assigned crew numbers, if available), planned survey areas for the day, potential access exemptions, and time and place of return. Throughout the course of the day, it is wise to check-in with the VIS to update float plan timing or location changes. At the end of the day, once the *Fog Lark* is moored in its evening location, the VIS is contacted for closing the float plan and is given an approximate time for the next morning's float plan activation. These general float plan principles apply to any vessel used during at-sea surveys within GLBA. When in doubt whether to contact the VIS regarding a boating update, the rule is to always make contact.

At the beginning of each day, after preparing the vessel for departure and warming up the outboard motors, the Boat Pilot should complete a log book entry that includes the same float plan information given to the VIS, the hour meter reading for each motor, and fuel consumption since refueling. The log book should be located near the driver's side console. Throughout the day, it is useful to log travel times and fuel consumption to distant locations to help gauge when the next refueling may be necessary. The *Fog Lark* has a 200-gallon fuel capacity and hence large range. But, because Glacier Bay is prone to rough weather and

long travel distances, fuel consumption needs to be closely monitored. Typically, a full tank allows travel from Bartlett Cove, up both arms of the bay, and back to Bartlett Cove.

SOP 2: Field Data Observer Forms

Version 1.0

Revision History Log:

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

Summary

The complete sets of paper data observer forms that have been accumulating over the survey period are scanned into a single PDF for the year. The PDF is submitted through the validation / quality assurance iterations until certified. It is stored in the repository and disseminated over the web.

SOP 2 requires users to work in the internal NPS network under valid Active Directory accounts. Access questions should be directed to the Data Manager.

Detailed Steps

A. Project Leader (or delegate) Tasks

1. Collect in one place the field observer forms that have been recorded during the field surveys for the year.
2. Review header information of each form and fill in any missing information using the NPTransect file geodatabase.
3. Arrange observer forms in alphabetic transect ID order, realizing if 2-sided forms are used this can only be approximate.
4. Verify the set is complete. There should be at least one sheet for every transect. If a sheet is missing and cannot be found after diligent search, insert a sheet of paper in the stack listing the transect ID and stating "No Field Observer Form." Any forms referring to the TST transect (used for testing only) are to be discarded.
5. Build a preface page summarizing any data recording issues that may affect interpretation of this year's data.
6. Scan the entire packet into a single PDF file using a color scanner and associated software.
 - a. Be sure the scanner is set for two-sided scanning, or be prepared to duplex them by hand.
 - b. Save the PDF on the SEAN network at \\inpglbafs03\data\SEAN_Data\Work_Zone\KM\Data\KM_B\yyyy where yyyy is the survey year covered, e.g., 2011. Name the file "KM_B_yyyy.PDF", once again substituting the year for yyyy.
 - c. Edit the PDF file to put sheets in transect name alphabetic order.

7. Request validation by sending a notification email to the Data Manager, specifying in the message body that deliverable KM_B, for year yyyy is ready; the Data Manager will know to work with the file named "KM_B_yyyy.PDF".

B. Data Manager Tasks

1. On receipt of the submission, assign the next formal Submission Number to this file, as found in the master Submission_Log table.
 - a. Use the "Update Submission Log" web tool at http://165.83.57.239/0_submission_update.aspx.
 - b. Complete Submission_Log details up through the Submission_Date column.
2. Copy the file into the staging area for validation at a subdirectory named with the submission number in \\inpglbafs03\data\SEAN_Data\Staging\KM\KM_B.
3. Validate the submission according to current criteria.
4. Record validation summary data in the Submission_Log using the web tool.
5. If submission fails mandatory criteria, reply with a "failure email" that includes:
 - a. The submission number assigned
 - b. The deliverable ID
 - c. The protocol ID
 - d. Documentation listing all the specific mandatory criteria failed
6. If submission passes mandatory criteria, reply with a "success email" that includes:
 - a. The submission number assigned
 - b. The deliverable ID
 - c. The protocol ID
 - d. Documentation listing any specific optional criteria failed
 - e. Request to certify deliverable as complete

C. Project Leader Tasks

1. On receipt of a failure email:
 - a. Review the paper stack is in order.
 - b. Rescan the PDF to ensure it is in the proper form.
 - c. Resubmit
 - d. If failure cannot be resolved, email the Data Manager that the submission is withdrawn.
2. On receipt of a success email, review any failed optional criteria:
 - a. The following tasks are the responsibility of the Project Leader and may not be delegated.
 - b. If the criteria review indicates the validated data are acceptable:
 - i. Reply with a "certification email" stating the deliverable is certified and may be disseminated.
 - c. If the validated data are unacceptable:
3. Reply with a "withdrawal email", stating the deliverable is withdrawn.
4. Take remedial action to obtain a corrected deliverable.
5. Restart the process from the beginning.

D. Data Manager Tasks

1. On receipt of a withdrawal email:

Glacier Bay National Park and Preserve Kittlitz's Murrelet Monitoring Protocol Version KM-2012.1

- a. Mark the withdrawal in the Submission_Log's Status column using the web tool.
- b. Terminate the process.
2. On receipt of a certification email:
 - a. Information cannot be disseminated. (Sensitivity is highly unlikely for this deliverable.) If sensitive:
 - i. Mark the sensitive designation in the submission status column using the web tool.
 - ii. Notify the submitter of the situation.
 - iii. Complete the deliverable tracking spreadsheet cells referring to dissemination with the word SENSITIVE.
 - iv. Do not attempt to install the sensitive item in the auxiliary repository.
 - b. Copy the submitted file to test environment at AUXREP\KM\KM_B\ .
 - c. Create an appropriate web link accessible from the KM main page.
 - d. Test accessibility until successful, then propagate from test to production environment.
 - e. Verify deliverable is accessible from production web site.
 - f. Mark the certification in the Status column in Submission_Log using the web tool.
 - g. Update the deliverable tracking spreadsheet milestones with the date of completion for KM_B.
3. Update the scope of the formal metadata so it includes this new date range

SOP 3: Raw Observations (KM_C Creation)

Version 1.0

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
	November 2012	S. Hoekman, W. Johnson, B. Moynahan, C. Sergeant	Initial version		1.0

Summary

During annual field work, observations are recorded directly to laptop computer using specialized software which is installed at the start of each season. The resulting data set, with no editing performed beyond correcting recognized data entry errors in the field, is called the raw observations. It is ultimately maintained on the laptop in the form of an ESRI “file geodatabase.”

At the end of the field effort, the resulting geodatabase is downloaded from the field computer onto NPS network storage. The group of files containing the season’s data as a geodatabase is zipped into a single file. This is submitted through the validation iterations until certified. On certification, the final product is made available for web dissemination.

SOP 3 requires users to work in the internal NPS network under valid Active Directory accounts. Network access questions should be directed to the Data Manager.

Detailed Steps

A. Project Leader Tasks

1. Verify all field work is complete, and the laptop’s geodatabase has had all “ArcMobile” cache data synchronized, as outlined in SOP 1.
2. Connect the field computer to the NPS network and log in.
3. Using Windows Explorer, copy the laptop directory C:\KIMU\MURRELETS.GDB to [\\inpglbafs03\data\SEAN_Data\Work_Zone\KM\KM_C\yyyy\](#) where yyyy is the survey year covered, e.g., 2011.
4. Check the overall file copy success by right-clicking the destination folder using Windows Explorer and noting its file size as shown by the Properties menu task. Verify this matches the size of the source C:\KIMU\MURRELETS.GDB. Take any actions necessary to correct incomplete copies.
5. Using desktop tools, create a ZIP file of the MURRELETS.GDB folder in [\\inpglbafs03\data\SEAN_Data\Work_Zone\KM\Data\KM_C\yyyy\](#).
 - a. Create it in the same ...\KM_C\yyyy\ folder.
 - b. Name the ZIP file KM_C_yyyy.ZIP

6. Request validation by sending a notification email to the Data Manager, specifying in the message body that deliverable KM_C, for year yyyy is ready; the Data Manager will know where to find the file named "KM_C_yyyy.ZIP".

B. Data Manager Tasks

1. On receipt of the submission, assign the next formal Submission Number to this file, as found in the master Submission_Log table.
 - a. Use the "Update Submission Log" web tool at http://165.83.57.239/0_submission_update.aspx.
 - b. Complete Submission_Log details up through the Submission_Date column.
2. Copy the folder containing the ZIP file as well as the MURRELETS.GDB directory into the staging area for validation at a subdirectory named with the submission number in \\inpglbafs03\data\SEAN_Data\Staging\KM\KM_C.
3. Validate the submission according to current criteria defined for KM_C in Appendix H of the protocol.
4. If submission fails mandatory criteria, reply with a "failure email" that includes:
 - a. The submission number assigned
 - b. The deliverable ID
 - c. The protocol ID
 - d. Documentation listing all the criteria failed
5. If submission passes mandatory criteria, reply with a "success email" that includes:
 - a. The submission number assigned
 - b. The deliverable ID
 - c. The protocol ID
 - d. Documentation listing any specific optional criteria failed
 - e. Request to certify deliverable as complete

C. Project Leader Tasks

1. On receipt of a failure email:
 - a. Be aware the purpose of this deliverable is to capture the exact record of field work. As such, mandatory criteria are deliberately made extremely loose and it is unlikely a submission will fail.
 - b. Review the validation report and remedy the mandatory errors. Consult the Data Manager to determine solutions, if necessary. These may require use of the daily thumb drive GDB/cache backups made in the field.
 - c. Initiate a new submission with the Data Manager.
2. On receipt of a success email, review any failed optional criteria:
 - a. If these are acceptable:
 - i. Reply with a "certification email" stating the deliverable is certified and may be disseminated.
 - b. If these are unacceptable:
 - i. Reply with a "withdrawal email", stating the deliverable is withdrawn.
 - ii. Take remedial action to obtain and resubmit a corrected deliverable, if possible.

D. Data Manager Tasks

1. On receipt of a withdrawal email:
 - a. Mark the withdrawal in the Submission_Log's Status column using the web tool.
 - b. Terminate the process.
2. On receipt of a certification email:
 - a. Verify no sensitive information is in the deliverable. Products containing sensitive information cannot be disseminated. (This deliverable is not currently classed as sensitive, but may be in the future .) If sensitive:
 - i. Mark the sensitive designation in the submission status column using the web tool.
 - ii. Notify the submitter of the situation.
 - iii. Complete the deliverable tracking spreadsheet cells referring to dissemination with the word SENSITIVE.
 - iv. Do not attempt to install the sensitive item in the auxiliary repository.
 - b. Copy the certified ZIP file to integration environment at AUXREP\KM\KM_C\
 - c. Create an appropriate web link accessible from the integration server KM main page.
 - d. Test accessibility until successful, and then propagate the KM_C file and its link from integration to production environment.
 - e. Verify deliverable is accessible from the production web site.
 - f. Mark "Certified" in the Status column in Submission_Log using the web tool. Also revise any previous certification record for this unit to "decertified."
 - g. Update the deliverable tracking spreadsheet milestones with the date of completion for KM_C.
3. Update the scope of the formal metadata so it includes this new date range.

SOP 4: Corrected Observations (KM_D Creation)

Version 1.0

Revision History Log:

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

Summary

This deliverable is based on the raw observations collected by field laptops. A copy is made of the KM_C file geodatabase. To that basis are added individual corrections that were noted on the field data forms (KM_B) but could not be entered in the field. Some corrections may also require data from waypoints, either directly off the field GPS unit designated for recording waypoints, or from the waypoints file (KM_I) if it is available.

An ASCII CSV file is generated from the corrected geodatabase by an application written for the purpose. Additional attributes are added for data quality codes and data quality comments. Both the final geodatabase and CSV are submitted through the validation / quality assurance iterations until certified. Be aware the validation criteria here are much stricter than those for KM_C and several iterations may be required to attain validation. The certified deliverable is stored in the repository and disseminated over the web.

It is recommended KM_D be generated post-season after the KM_C deliverable has been field corrected and certified. If the KM_C product is ever determined to be flawed, then KM_D will have to be regenerated from the corrected geodatabase.

SOP 4 requires users to work in the internal NPS network under valid Active Directory accounts. Network access questions should be directed to the Data Manager.

Detailed Steps

A. Project Leader (or Delegate) Tasks

1. Edit corrections into the raw observation geodatabase
 - a. Verify these precursors are available:
 - i. Either the certified KM_C geodatabase or the final C:\KIMU\Murrelets.gdb folder from the field laptop.
 - ii. Either the certified KM_I waypoints file or the original field GPS.
 - iii. Either the certified KM_B field data observer form images or the complete set of physical forms.
 - b. Download the completed KM_C deliverable MURRELETS.GDB directory from the production server if available to \\INPGLBAFS03\Data\SEAN_Data\Work_Zone\KM\KM_D\yyyy and then unzip

- it. Alternatively, obtain C:\KIMU\Murrelets.gdb folder from the field laptop if a certified KM_C is not yet available.
- c. Copy the latest MURRELETS.MXD file available into
\\INPGLBAFS03\Data\SEAN_Data\Work_Zone\KM\KM_D\yyyy
- d. Apply corrections to the geodatabase.
 - i. Start the ESRI ArcMAP application on a workstation.
 - ii. Open the MURRELETS.MXD map file
 - iii. Be sure the following features are properly resolved in the map (if not, the source in the layer properties must be adjusted to point to the geodatabase object):
 - 1. Bird groups
 - 2. GPS points
 - 3. Observations
 - 4. Tracks
 - 5. Transects
 - iv. Be sure there is adequate background imagery available to clearly visualize the features at high magnification.
 - 1. If the workstation is connected to the NPS network, it will often find the imagery on the X: drive.
 - 2. If X: drive imagery is not available, copy C:\KIMU\UserData\GLBA_Cache \ into \\INPGLBAFS03\Data\SEAN_Data\Work_Zone\KM\KM_D\yyyy and see that the source is linked to the map feature named "Background Imagery".
 - 3. It is also possible to employ different imagery found on, say, the ESRI World Imagery Service.
 - v. Edit the file geodatabase in ArcMAP
 - 1. Apply all corrections from the KM_B field logs that were not already taken care of in the field.
 - 2. Verify tracklogs are attributed to the correct transect
 - i. Be sure the Transects and Tracks features are visible over the imagery.
 - ii. Open the Tracks attribute table and sort it by Transect ID
 - iii. Select one at a time each line of the attribute table
 - iv. Verify each selected row appears highlighted on the map as part of the correct transect. That is, the Transect ID in the table must match the Transect number on the map.
 - v. For any row that was physically recorded on a different transect, edit the proper Transect ID into the table entry. The visual location comes from the GPS (bulletproof) while the transect table entry was typed by hand in the field (fragile).
 - 3. Extend tracklog segments to cover gaps that resulted from application or GPS interruptions.

- i. For each transect used that year, magnify it so missing tracklog segments may be seen.
 - ii. Edit the Tracks feature where necessary to extend one of the tracklogs so it snaps with the start of the next tracklog along the transect, filling the gap.
 - iii. Never extend an "off transect" tracklog over an observation.
4. Audit the "On Transect" attribute of Tracks.
 - i. Visually determine locations where the boat is going along the transect correctly, but the tracklog has On Transect set to false. Be aware there are legitimate reasons the boat may be physically on the transect but has temporarily suspended operation, as when waiting for an obstruction to clear or a technical problem to be resolved: check KM_B for explanations. A good way to see them is to open the Tracks table, sort by "On Transect" and zoom to each "False" track.
 - ii. Visually determine where the boat is not physically near the transect, but On Transect is set to true.
 - iii. Correct errors by editing individual On Transect values in the Tracks attribute table.
 - iv. Never assign a tracklog "off transect" when an observation is on it.
 - v. In the case where a single tracklog is set to one value but spans both on- and off-transect states, the editing software must be used to split the tracklog into two before assigning the correct state to the flawed section.
5. Correct any observations determined to be made off transect.
 - i. Sort the Tracks table by "On Transect."
 - ii. Select the block having False for on transect.
 - iii. Use the "related tables" function to drill down to GPS Points, and then to Observations. The Observations should be empty.
 - iv. If observations are found related to off transect, make appropriate corrections.
6. Force consistent representation of Protocol ID, Vessel Name, Data Recorder, and Observers in the Tracks table. Be sure they all reflect upper case.
7. Edit the Bird Groups feature so that any remaining Species of "Pending" is set to "Unidentified". (Locate by visually checking the Bird Groups layer for any red icons.)
8. Delete any test transect data. (The specific method, below, assures referential integrity will be maintained, so it is highly preferred.)
 - i. Open the attribute table for TRANSECTS and select transect "TST".

- ii. Cycle through the relations until the last object, BIRD GROUPS, shows on the screen. The table reflects the number of bird groups selected, which should be on the order of a few percent of all groups.
 - iii. Delete the selected.
 - iv. Back up to OBSERVATIONS. Verify a reasonable number are selected and delete them.
 - v. Back up to GPS POINTS. Verify a reasonable number are selected and delete them.
 - vi. Back up to TRACKS. Verify a reasonable number are selected and delete them.
 9. Be sure all edits have been saved.
 10. Verify the integrity of the FGDB
 - i. Open the Transect table and select all rows
 - ii. Next drill the "Related Table" Track and be sure all rows have been selected.
 - iii. Next drill the "Related Table" GPSPoint and be sure all rows have been selected.
 - iv. Next drill the "Related Table" Observation and be sure all rows have been selected.
 - v. Next drill the "Related Table" BirdGroups and be sure all rows have been selected.
 - vi. If any table shows more rows present than are selected, then those rows are orphans in the database structure and must be either attached to parents or deleted entirely.
 11. Close ArcMap.
2. Create the CSV file
- a. Locate a machine that has the NPTransect application installed on it. NPTransect must always be installed on the root level of the C: drive.
 - b. Replace the application's geodatabase content at C:\KIMU\Murrelets.gdb\ with the corrected version from \\INPGLBAFS03\Data\SEAN_Data\Work_Zone\KM\KM_D\yyyy\Murrelets.gdb.
 - c. From a DOS command box on the application machine, execute the script C:\KIMU\Scripts\4)ExportToCSV.bat.
 - d. Verify a file was created in C:\KIMU\CSV\ with the current date and time.
 - e. Open the file in Excel and verify it has content of the expected form.
 - f. Copy the file from C:\KIMU\CSV\ to \\INPGLBAFS03\Data\SEAN_Data\Work_Zone\KM\KM_D\yyyy .
 - g. Rename the file to KM_D_yyyy.CSV.
 - h. Open the CSV file on \\INPGLBAFS03\ in Excel.
 - i. Set the TRANSECT_ID column's cell format to "custom 000" in order to preserve any leading zeroes in the transect name when it is resaved.

- j. Correct the heading typo on the first row: DATA_QUALITY_CODE should be changed to DATA_QUALITY_COMMENT.
 - k. Fill the DATA_QUALITY column with zero for every row (presume they're good).
 - l. Save the sheet as type CSV (comma delimited).
 - i. If Excel prompts whether you really want to save it as CSV, click Yes.
 - ii. Close Excel.
3. Insert quality information into the CSV file
- a. Reopen the CSV file on \\INPGLBAFS03\... in Excel.
 - b. Bring up the associated field data observer form, either as the images of KM_B on the web site or as original paper forms.
 - c. Record any data quality issues indicated on the observer forms to the data file.
 - i. For any rows that are of questionable accuracy fill Data_quality with the digit 4, and add Data_quality_comment text explaining why it is questionable. Questionable data include:
 1. Observations noted as exceptional on the field observer form.
 2. Observations reconstructed from paper backup used because the automated recording system failed.
 3. Distances that are not multiples of 10, which suggest typos.
 4. Angles that are not multiples of 5 suggesting typos – except 171 through 189, which should be resolved to the single digit.
 - ii. For rows that are corrupted or have lost required data, as may occur through hardware failure, mark Data_quality with the digit 8, and add Data_quality_comment text explaining why it is unusable. Questionable data include:
 1. Observations noted as invalid on the field observer form.
 2. Angles of 0 or 360, which are not visible to observers.
 3. Note: Data_quality 8 rows are not stored in the repository database (KM_E).
 - iii. For rows that have no corresponding field log form, mark Data_quality with the digit 1, and add Data_quality_comment text explaining why the quality is unknown.
 - iv. In the event of equipment failure that required paper recording of observations along with waypoint recording on the GPS:
 1. If no file with any content was captured at all, initiate a blank CSV file in Excel with the heading row copied from a prior year file.
 2. Regardless, insert rows into the spreadsheet reflecting as much data as was recorded on paper in chronological sequence.
 3. Use the waypoint identifiers on the form to look up the location and time on the GPS unit or KM_I waypoint file – converting time and coordinates to match units specified in Appendix I if needed.
 4. Mark the Data_quality as 4.
 5. Mark Data_quality_comment “automated data collection failed”.
 - d. Resave the corrected file as CSV and close Excel.

4. Create KM_D by zipping together in place both the corrected GBD folder and the edited CSV file. Name the ZIP file "KM_D_yyyy.ZIP".

B. Project Leader Tasks

1. Request validation by sending a notification email to the Data Manager, specifying in the message body that deliverable KM_D, for year yyyy is ready; the Data Manager will know where to find the file named "KM_D_yyyy.ZIP".

C. Data Manager Tasks

1. On receipt of the submission, assign the next formal Submission Number to this file, as found in the master Submission_Log table.
 - a. Use the "Update Submission Log" web tool at http://165.83.57.239/0_submission_update.aspx .
 - b. Complete Submission_Log details up through the Submission_Date column.
2. Copy the file into the staging area for validation at a subdirectory named with the submission number in [\\inpglbafs03\data\SEAN_Data\Staging\KM\KM_D](http://inpglbafs03\data\SEAN_Data\Staging\KM\KM_D).
3. Validate the submission according to current criteria.
 - a. Invoke validation of the CSV file according to current criteria by using the web program at http://165.83.57.239/KM_DM_validate_KMD.aspx
 - b. Validation summary results automatically are recorded in the Submission_Log.
4. If submission fails mandatory criteria, reply with a "failure email" that includes:
 - a. The submission number assigned
 - b. The deliverable ID
 - c. The protocol ID
 - d. Documentation listing all the criteria failed
5. If submission passes mandatory criteria, reply with a "success email" that includes:
 - a. The submission number assigned
 - b. The deliverable ID
 - c. The protocol ID
 - d. Documentation listing any specific optional criteria failed
 - e. Request to certify deliverable as complete

D. Project Leader Tasks

1. On receipt of a failure email:
 - a. Review the validation report and remedy the mandatory errors.
 - i. In case it is impossible to correct a mandatory error on a particular row of the CSV file:
 1. Mark its Data_quality with the digit 8.
 2. Record a Data_quality_comment explaining why it cannot be corrected.
 3. Be aware the cumulative database will not accept this row.
 - b. Initiate a new submission with the Data Manager.
2. On receipt of a success email, review any failed optional criteria:
 - a. If the criteria review indicates the validated data are acceptable:
 - i. Reply with a "certification email" stating the deliverable is certified and may be disseminated.

- b. If the validated data are unacceptable:
 - i. Reply with a "withdrawal email", stating the deliverable is withdrawn.
 - ii. Take remedial action to obtain and resubmit a corrected deliverable, if possible.

E. Data Manager Tasks

- 1. On receipt of a withdrawal email:
 - a. Mark the withdrawal in the Submission_Log's Status column using the web tool.
 - b. Terminate the process.
- 2. On receipt of a certification email:
 - a. Verify no sensitive information is in the deliverable. Products containing sensitive information cannot be disseminated. If sensitive:
 - i. Mark the sensitive designation in the log's submission status column using the web tool.
 - ii. Notify the submitter of the situation.
 - iii. Complete the deliverable tracking spreadsheet cells referring to dissemination with the word SENSITIVE.
 - iv. Do not attempt to install the sensitive item in the auxiliary repository.
 - b. Copy the submitted file to the development environment at AUXREP\KM\KM_D\ .
 - c. Create an appropriate web link accessible from the KM main page.
 - d. Test accessibility until successful, then propagate from development to integration and then to the production environment.
 - e. Verify deliverable is accessible from production web site.
 - f. Mark the certification in the Status column in Submission_Log using the web tool. Mark any prior certified submission for this unit as decertified.
 - g. Update the deliverable tracking spreadsheet milestones with the date of completion for KM_D.
- 3. Update the scope of the formal metadata so it includes this new date range.

SOP 5: Waypoints (KM_I Creation)

Version 1.0

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
	November 2012	S. Hoekman, W. Johnson, B. Moynahan, C. Sergeant	Initial version		1.0

Summary

In the course of the annual field work, one hand-held GPS unit records waypoints for two purposes. First, it is pre-loaded with waypoints marking the beginning and ending location of each transect segment to be covered that season. These are used as emergency backup should the main navigation equipment fail. Second, field crew records waypoints to mark the location of exceptions encountered during surveys. Exceptions include pausing along a transect, encountering physical obstacles, and taking manual observations after automated recording systems fail among others.

At the end of season, a comma-delimited ASCII text file of the exception waypoints is downloaded from the GPS unit into NPS network storage. The text file is submitted through the validation / quality assurance iterations until certified. It is stored in the repository and disseminated over the web.

The detailed steps, below, have been tested using Garmin GPS 76s equipment and DNRGarmin 5.4.1 software. Different gear may require adaptations to the steps.

SOP 5 requires users to work in the internal NPS network under valid Active Directory accounts. Access questions should be directed to the Data Manager.

Detailed Steps

A. Project Leader (or delegate) Tasks

1. Connect the field GPS unit using a serial cable to a computer that is logged into the NPS network and then power up the GPS.
2. Start the DNRGarmin application on the computer – if the GPS is not automatically found, use the GPS menu item to set proper serial port and/or speed.
3. Use the FILE / SET PROJECTION menu item to set UTM zone 8N.
4. Under the WAYPOINT menu item, select DOWNLOAD and wait for the file to be fully read.
5. Select those rows on the DNRGarmin table that refer to KIMU exception waypoints taken during the field season.
6. Under the FILE menu item select SAVE TO and then FILE... Use the destination location \\inpglbafs03\data\SEAN_Data\Work_Zone\KM\Data\KM_I\yyyy where yyyy is the survey

- year covered, e.g., 2011. Name the file "KM_I_YYYY.TXT", once again substituting the year for YYYY. Be sure the Save Type is "Text File (Comma Delimited)."
7. When the save is complete, use Windows Explorer to rename the file's extension to ".CSV". (Attempting to save the file using DNRGarmin with an explicit CSV extension alters the format of the file.)
 8. Verify the file transfer was successful and standardize certain names.
 - a. Open the file in an ASCII text editor such as Notepad – do not use a word processor or other software that could reformat the file.
 - b. Observe that the first header line contains column names.
 - c. Observe there are subsequent lines of data and their content appears consistent with the column names.
 - d. Observe that only KIMU field-taken waypoints are in the file. Other waypoints, such as any backup transect endpoints or waypoints left over from other projects, must not appear in this file.
 - e. Because different GPS units format waypoint records differently, the column names in the first line usually must be edited to exact standard titles that subsequent automated processing are expecting to find and interpret. Waypoint files typically contain the basic data we require plus additional columns: ignore the extra data and work with the following four attributes only.
 - i. The column containing the unique waypoint id should have its heading set to WAYPOINT_ID.
 - ii. The column containing the latitude should have the heading LATITUDE.
 - iii. The column containing the longitude should have the heading LONGITUDE.
 - iv. The column containing the date followed by time should have the heading TIMESTAMP.
 - f. Close the editor, saving changes if they were made.
 9. Request validation by sending a notification email to the Data Manager, specifying in the message body that deliverable KM_I, for year YYYY is ready; the Data Manager will know to work with the file named "KM_I_YYYY.CSV".

B. Data Manager Tasks

1. On receipt of the submission, assign the next formal Submission Number to this file, as found in the master Submission_Log table.
 - a. Use the "Update Submission Log" web tool at http://165.83.57.239/0_submission_update.aspx.
 - b. Complete Submission_Log details up through the Submission_Date column.
2. Copy the file into the staging area for validation at a subdirectory named with the submission number in \\inpglbafs03\data\SEAN_Data\Staging\KM\KM_I.
3. Validate the submission according to current criteria.
 - a. If the file name does not fit the form defined above, that is grounds for immediate failure.
 - i. Do not attempt to further validate it.
 - ii. Mark the submission status as failed using the web tool.
 - iii. Return a failure email as described below.

- a. Mark the withdrawal in the Submission_Log's Status column using the web tool.
- b. Terminate the process.
2. On receipt of a certification email:
 - a. Verify no sensitive information is in the deliverable. Products containing sensitive information cannot be disseminated. (Sensitivity is highly unlikely for this deliverable.) If sensitive:
 - i. Mark the sensitive designation in the submission status column using the web tool.
 - ii. Notify the submitter of the situation.
 - iii. Complete the deliverable tracking spreadsheet cells referring to dissemination with the word SENSITIVE.
 - iv. Do not attempt to install the sensitive item in the auxiliary repository.
 - b. Copy the submitted file to test environment at AUXREP\KM\KM_I\.
 - c. Create an appropriate web link accessible from the KM main page.
 - d. Test accessibility until successful then propagate from test to production environment.
 - e. Verify deliverable is accessible from production web site.
 - f. Mark the certification in the Status column in Submission_Log using the web tool.
 - g. Update the deliverable tracking spreadsheet milestones with the date of completion for KM_I.
3. Update the scope of the formal metadata so it includes this new date range.

SOP 6: Cumulative Database (KM_E Creation)

Version 1.0

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
	November 2012	S. Hoekman, W. Johnson, B. Moynahan, C. Sergeant	Initial version		1.0

Summary

After certification of a KM_D submission, the CSV corrected observation file remains available in the staging area. Data in this file are loaded into the staging cumulative database, after deleting any previous submission for the subject year. Once that is done successfully, the staged updated submission content is propagated to the production database.

Loading is performed by an automated process. The input CSV file is examined before being loaded. The input KM_D file must meet mandatory criteria before any attempt is made to update the database with it. KM_E database content is solely based on certified KM_D data files. Certification of KM_D is inherited by KM_E, and the application automatically marks database content as certified.

All steps are performed by the Data Manager.

Detailed Steps

A. Data Manager Tasks

1. Before attempting to update the cumulative database, verify the year's certified KM_D corrected data file is still intact in the staging area. KM_E database updates can only come from certified staged KM_D files.
2. If the KM_D deliverable for the submission unit was marked sensitive in its Submission_Log entry:
 - a. Create a Submission_Log entry for this KM_E using the web tool, marking its status also as sensitive.
 - b. Update the annual deliverable tracking spreadsheet with the date of completion for KM_E.
 - c. Propagate only the tracking spreadsheet to production.
 - d. The process is complete – no data are actually added to the database.
3. Otherwise use web application http://165.83.57.239/KM_DM_create_KM_E.aspx on the management site to create and validate the KM_E.
 - a. Indicate to the program which certified KM_D submission from the offered choices to use as the basis for the KM_E.
 - b. The submission log entry will be automatically created and updated by the application as progress is made.

- c. The KM_D components are revalidated
 - i. If a mandatory criterion is violated, the KM_E will not be created and the process ends.
 - ii. Failure suggests either undetected flaw in the predecessor KM_D or a KM_D that was altered after it received certification. The issue must be investigated and corrected before a KM_E can be created for the year.
 - d. If this submission unit has previously been stored in the database, then the new data will totally replace the older year submitted
 - i. The web application will only erase/replace the earlier data if the operator confirms this with the "overwrite" button on the screen.
 - ii. Should loading of the new data fail later in the process, any erased prior data will remain erased. Remedial action, such as correcting the underlying KM_D, will be needed to repopulate the submission unit (i.e., year).
 - e. Once the tasks performed by the application complete, their results are automatically documented in a findings file stored in the same folder as the underlying staged KM_D data file.
 - f. When complete, the web application updates the submission status.
 - i. If it is not Certified, check the screen or the findings file to determine the nature of the problem, correct the issue, and resubmit.
4. Using SQL Server management studio, update the production database rows and submission log entry for the submission unit from the staging server.
 - a. Connect to the staging server.
 - b. Be sure the production server is accessible as a "linked server".
 - c. Delete from the production server WHERE YEAR=yyyy.
 - d. INSERT INTO production.table SELECT * from staging.table WHERE YEAR=yyyy.
 - e. Select some data from the production table to verify it has been populated.
 5. Update the annual deliverable tracking spreadsheet with the date of completion for KM_E and propagate it to production.
 6. Update the scope of the formal metadata so it includes the new date range and propagate it to production.

SOP 7: Annual Report (KM_G: Annual report creation)

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

The annual report disseminates up-to-date information from the SEAN murrelet monitoring program to NPS staff and resource managers, external scientists, and the general public. For each survey year, the report summarizes field efforts, present statistical analyses of survey data related to status, trend, and distribution for KIMU and MAMU populations in Glacier Bay. After July surveys and certification of data and data analyses, the Project Leader generates the annual report.

Report generation requires substantial prior statistical analyses, as described in SOPs 11 and 12. Inputs for analyses are the current survey year’s transects (in KM_A: Target transects), observations and trackpoints (in KM_E: Cumulative observation database), and waypoints recording exceptional events (in KM-I: Waypoints). Analyses produce descriptive statistics summarizing survey effort and characteristics of the sample, estimates of component parameters used for population estimates (detection probability, group size, encounter rates), species-specific estimates of on-water density and abundance, and maps summarizing spatial distributions of populations. Outputs from the report generation process include data deliverables KM_J: Detection function and KM_K: Abundance estimates.

Format and Content

The annual report is formatted as a NPS Natural Resource Technical Report (see National Park Service 2010, available at <http://www.nature.nps.gov/publications/NRPM/>) and contains the following sections:

- I. **Introduction:** Overview of the purpose, objectives, prior results, and any substantive changes to the monitoring program (e.g., new personnel, equipment, or methods).
- II. **Methods:** Brief summary detailing the survey design, field methods, timing of field work, panels sampled, equipment and personnel employed, and analytic methods.
- III. **Results:** Summary statistics and parameter estimates for the current year’s data, including information pertaining to sampling effort, field conditions, distribution of murrelet populations, and estimates of density and abundance, and spatial distribution of populations.
- IV. **Discussion:** Summary and interpretation of results relevant to management issues, technical aspects of the monitoring protocol, and public interest. Results should be placed in context of prior monitoring data and relevant scientific literature.
- V. **Recommendations (optional):** As needed, recommended refinements to the monitoring protocol or issues requiring further consideration (e.g., in six-year review).

As an example of an Annual Report, see Hoekman et al. (2013).

Statistical Analyses

The primary objective of statistical analyses is to use Distance Sampling (Buckland et al. 2001, 2004) to estimate on-water density and abundance of each murrelet species within the survey area. Initial steps involve estimating several component parameters (Table SOP 7.1) that combine to produce density and abundance estimates. Analyses are automated as much as is practical, but exploratory analyses and judgment are required to ensure meeting critical assumptions and appropriate application of statistical methods. Our sampling methods require separate estimation of group sizes, density, and abundance for analyses of population status (density and abundance) versus population trend. Because periodic reviews (see SOP 8) include sophisticated analyses of population trend, we recommend annual reports focus on population status.

Detection Function and Group Size

Distance sampling allows estimation of a detection function and detection probability for murrelet groups across the transect width. Exploratory analyses ensure critical statistical assumptions are met and apply appropriate truncation and binning strategies. Model selection procedures are then used to select an appropriate model for estimation of the detection function. Step-by-step procedures and pre-defined templates for conducting analyses in Program DISTANCE (Thomas et al. 2010) are detailed in SOP 11. Distance sampling assumes detection probability near the transect center line is 1, but an estimate from prior research (Hoekman et al. 2011) provides an adjustment for this parameter actually being slightly <1 . Group size for each species class (Kittlitz's, marbled, and unidentified) is also estimated in Program DISTANCE. Based on statistical criteria, estimates of group size may be averages or be derived from regression analyses accounting for increased detection probability for larger groups.

Density and Abundance

Estimated detection probability and group size are then used in concert with estimated encounter rates (groups detected/km) to estimate on-water density and abundance for populations of each species. SOP 12 presents analytic methods developed to estimate species-specific encounter rates adjusted to account for unidentified murrelets and species-specific density and abundance. Computer code for the R Statistical Package (R Development Core Team 2011) expedites analyses (see Appendix D).

Content of Results Section

The Results section provides information for assessment of status, trend, and spatial distribution of murrelet populations in the Glacier Bay survey area and also provides technical information about the operating characteristics of this monitoring protocol. Contents should be flexible to include exceptional information, but should include the following core components:

Summary and Descriptive Statistics

Recommended summary results provide a synopsis of the surveys, including the timing of surveys, personnel involved, general weather and visibility conditions during surveys, and any other exceptional events or patterns relevant to collection or analyses of data or interpretation of results. Recommended descriptive statistics characterizing the sampling effort include: the number and total length of transects sampled, any scheduled transects that were not sampled, partially sampled, altered, or significantly disturbed.

Recommended descriptive statistics characterizing survey observations include: the number of groups

encountered for each species class and corresponding percent composition by class, overall identification rates (percent of murrelets identified versus unidentified), and the average size of groups by species class. Other summary statistics related to distance estimation calibration assessment (see SOP 9) may also be included to document performance of Observers.

Detection Function and Group Size

Relevant details of exploratory analyses are reported, including the selected right-truncation distance, distance bins (if any), and the model (key function and series expansion and associated parameter estimates) selected to estimate the detection function. The estimated detection function is presented in a figure along with associated scaled frequencies for the raw observation data (Figure SOP 7.1). For each species class, estimates of group size and associated output (SE, *df*, *P*-values) derived from both average group size and regression-based methods should be presented in text or a table, along with specification of which estimates were selected for population analyses.

Density and Abundance

The component parameters and associated sampling error used to estimate on-water density and abundance are presented in a unified table (Table SOP 7.1), which should include estimated detection probability near the transect center line and across the transect width and also estimates of group size and encounter rate. Estimates of detection probability near the center line likely will be taken from prior research (e.g., Hoekman et al. 2011). For each species class, only estimates of group size selected for population analyses should be presented in the Table. Estimated encounter rates for each species class should be presented along with encounter rates for each species adjusted to account for unidentified murrelets. Estimates of species-specific density (birds/km²) and abundance (extrapolated across survey area) along with associated sampling error are presented in a table with estimates for each survey year (Table SOP 7.2). A figure of abundance (\pm SE) for each survey year may also be useful to display variability in estimates.

Spatial Distribution of Populations

Maps showing the spatial distribution of observations of each species along survey transects are presented using symbols showing group sizes (Figure SOP 7.2). If densities of observations are too high, showing total individuals in an area rather than individual observations may be necessary. It may be useful to also display distributions from prior surveys or distributions depicting average prior densities, etc.

Content of the Discussion

The Discussion places the Results section in context of prior results for this and other regions, of relevant scientific literature, and of NPS policy. Abundance and spatial distributions of populations for each species are interpreted relative to prior local and global results. Although discussing effects of exceptional circumstances or hypotheses about causal factors for patterns in the Results are appropriate, the periodic review (SOP 8) will be the preferred outlet for analyses and conclusions concerning trends in populations and their spatial distributions. Addressing other salient topics, such as performance of survey methods or implications of Results for future surveys may also be useful.

Content of the Recommendations

Include as needed to provide recommendations relevant to future monitoring, such as: potential changes to monitoring methods, identification of key research needs, identification of management or policy issues requiring action or investigation, etc.

Validation and Submission

The final version of KM_G is generated as a PDF file and submitted to the Project Leader for standard validation and certification. Upon certification, the Data Manager will install the report in the repository and publish it on the NPS web site.

Literature Cited

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SOP 7 Figures and Tables

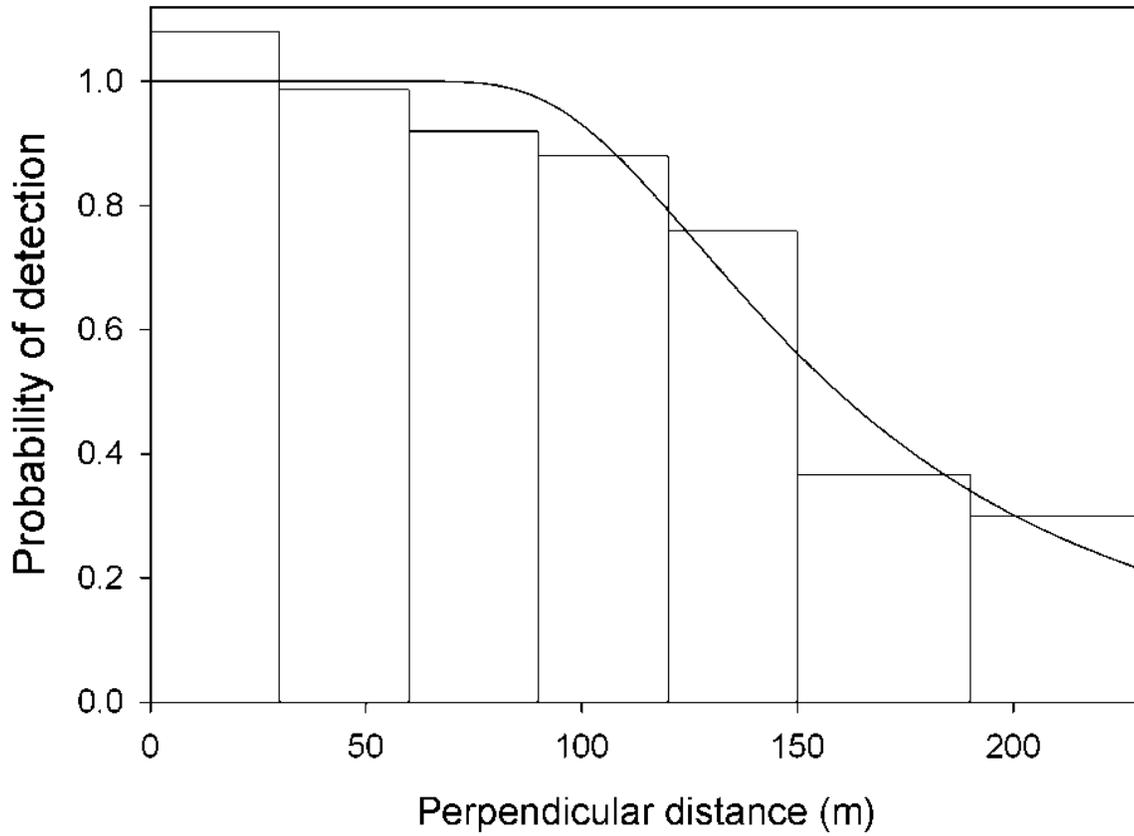


Figure SOP 7.1. Example of an estimated detection function (solid line) showing probability of detection of murrelet groups relative to perpendicular distance from the transect center line. Bars show the scaled frequencies of detections in each distance category for the raw data.

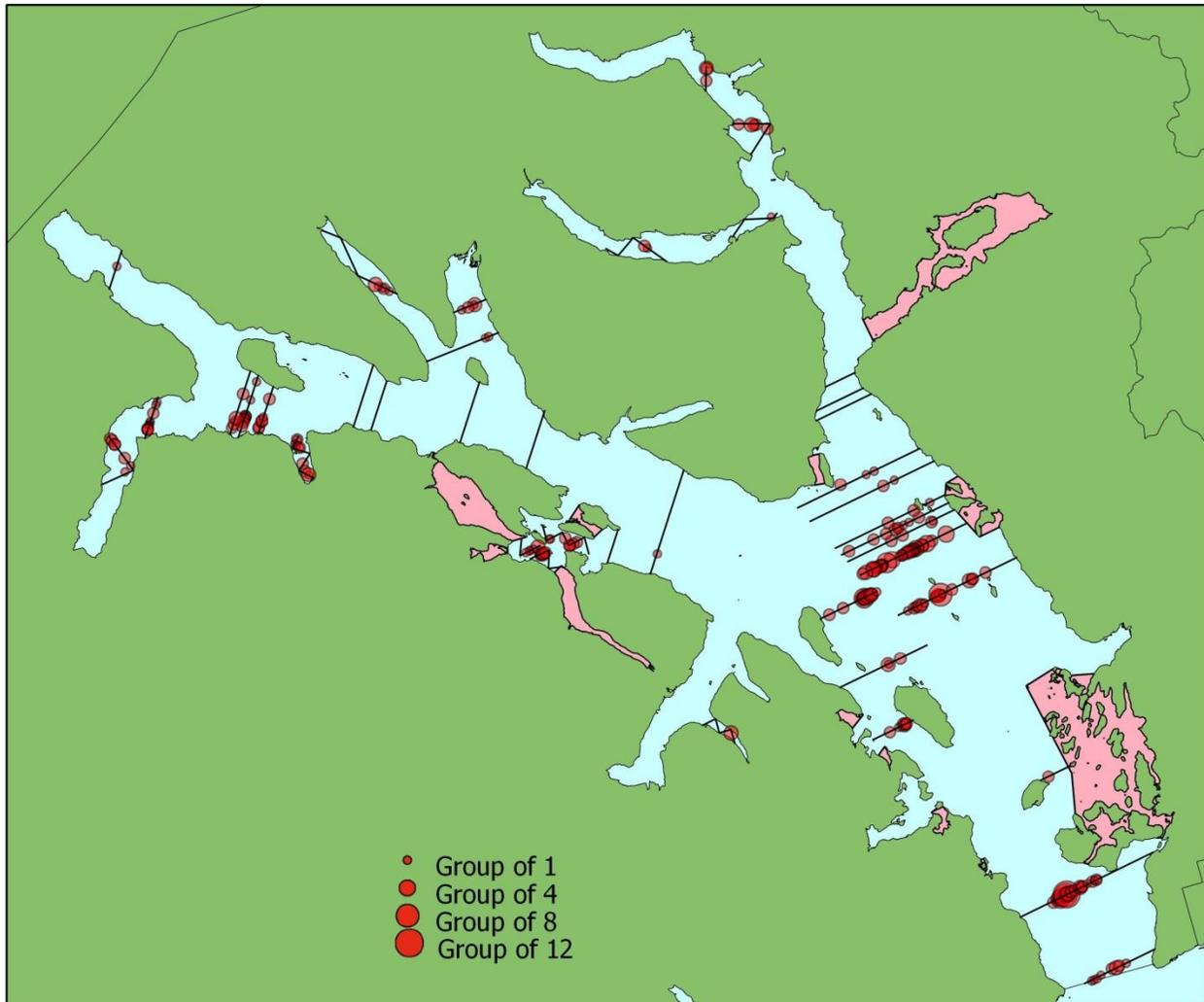


Figure SOP 7.2. Example of a map showing spatial distribution of murrelets along survey transects. Red circles show locations of groups, with the volume proportional to group size. Pale red areas were excluded from the survey area.

Table SOP 7.1. Example of table showing estimates for component parameters used to estimate on-water density and abundance for populations of Kittlitz's and marbled murrelets.

Parameter	Estimate	SE	Degrees of freedom
Detection across transect width	0.72	0.02	1,239
Detection near transect center line	0.94	0.03	66
Group size			
Kittlitz's murrelet	2.05	0.08	223
Marbled murrelet	2.50	0.07	723
Unidentified murrelet	3.45	0.26	292
Encounter rate ^a			
Kittlitz's murrelet	1.17	0.10	39
Marbled murrelet	4.71	0.41	39
Unidentified murrelet	1.66	0.14	39

^aGroups encountered per km.

Table SOP 7.2. Example table showing estimated on-water density and abundance of Kittlitz's and marbled murrelets in the Glacier Bay during July during each survey year. Abundance is projected across the survey area.

Year	Kittlitz's murrelet				Marbled murrelet			
	Density ^a	SE	Abundance ^b	SE	Density ^a	SE	Abundance ^b	SE
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

^aIndividuals/km².

^bAbundance extrapolated over the 1,170 km² survey area.

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 ($=w*\{100+\% \text{ bias in estimates}\}/100$). 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.

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SOP 9: Training Survey Personnel

Version 1.0

Revision History Log:

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

Summary

Training survey personnel requires a combination of pre-season and in-the-field preparation in order to ensure successful data collection and safety during field operations. In particular, Observers must develop and maintain required proficiencies, including murrelet identification, distance estimation, and on-transect data reporting. General knowledge of the larger context of data collection and analyses is also beneficial, including understanding assumptions of distance sampling, methods for abundance estimation, and basic operation of NPTransect software. When applicable, we refer to other portions of the protocol to provide more information.

General Observer Qualifications

Observers should have previous experience with field survey logistics, identification of birds using binoculars, and general outdoor safety. Surveys require observers to stand at the bow of an 8 to 10 m research vessel in variable sea and weather conditions using binoculars to detect, enumerate, and identify murrelets for up to 10 hours per day. Although no previous experience with murrelets or at-sea line transect surveys is required, inexperienced Observers will require extensive training, preferably with an experienced Observer.

New Observers should be familiar with objectives and general methods of this protocol, but should pay particular attention to the protocol narrative and SOP 1, which describes field methods for Observers. The protocol narrative provides background information and conservation context, justifies the KIMU monitoring program, and summarizes details of the sampling design and analytic methods. Upon completing training, Observers should be able to efficiently scan each transect using binoculars, work alone or in cooperation with other Observers, competently identify KIMU and MAMU, use the angle board, accurately estimate at-sea distances ≤ 200 m, and transmit observations to the Data Recorder using correct procedures.

Accurately Identifying Murrelets

KIMU and MAMU are cryptic species (sympatric with similar morphology and behavior) and cannot always be distinguished in the field. But with knowledge of identifying characteristics (Table SOP 9.1), photo study (Figures SOP 9.1, SOP 9.2), and practice in the field, Observers can confidently identify most individuals in typical survey conditions. It is important to remember that the SEAN sampling design allows Observers to classify murrelet observations as “unidentified.” This species class should be used when identification is

uncertain, on account of high murrelet density (i.e., insufficient time to identify each individual), difficult viewing conditions, or other factors. Misidentified murrelets incur greater risk of biasing population estimates than unidentified murrelets; therefore, murrelets should be classified to species only when confidence in identification is high. Use of the “unidentified” class is preferred to guessing species identity when identifying characteristics are not seen. Color of outer tail retrices is the primary diagnostic characteristic, but is visible only in the first few seconds after take-off from the water. Note both species may have white on flanks of rump or on undertail coverts. The “KEER” calls of MAMU are also diagnostic, but may be difficult to associate with individuals. Other identifying characteristics describe overlapping continuums between species and are best used in aggregate to inform species identification. Be aware changing lighting conditions can strongly influence impressions of bill length and especially overall coloration.

Surveys occur in early to mid-July, so the majority of murrelets will be in summer plumage, which is generally darker and more muted than black and white winter plumage. By mid-July, small numbers of juvenile murrelets may also be present on the water. In both cases, KIMU typically have black caps that do not include the eye, while MAMU typically have black caps including the eye, although plumages may be highly variable.

Table SOP 9.1. Main identifying characteristics of Kittlitz’s murrelets in summer plumage in comparison to marbled murrelets; adapted from K. Kuletz training presentation.

Identifying characteristic	Kittlitz’s murrelet	Marbled murrelet
Outer retrices	White	Dark brown
Bill length	Relatively short; hard to see at times	Relatively long
Head shape	Overall shape more triangular, blunt	More tapered toward bill
Overall color	Mottled; white/grey to tan/brown	Uniform chocolate to mixed tan/brown
Belly/flanks in flight	Mostly white to all white; high contrast between light underparts and dark wings	All dark to mostly dark
Call	Nasally, one-note, “MWAH” (rare)	High-pitched “KEER” or “KREE” (common)

Many representative photos of KIMU and MAMU exist that can aid in identification training. The SEAN plans on developing a visual training module in cooperation with other agencies and non-government organizations involved in KIMU surveys throughout Alaska. A future coordinated training effort will help ensure similar identification skills among murrelet survey observers across Alaska. At this time, future Observers will discuss the appropriate level of training and necessary review materials with the Project Leader before surveys begin. After a new Observer has studied photos, discussed murrelet identification with an experienced Observer, and completed existing training materials, the next step is field practice. Individuals with average field experience will likely devote a day to office study (including reading protocol materials) and two or three days to field practice.

No matter what training materials are available, the Project Leader determines whether an Observer is prepared to conduct field surveys.

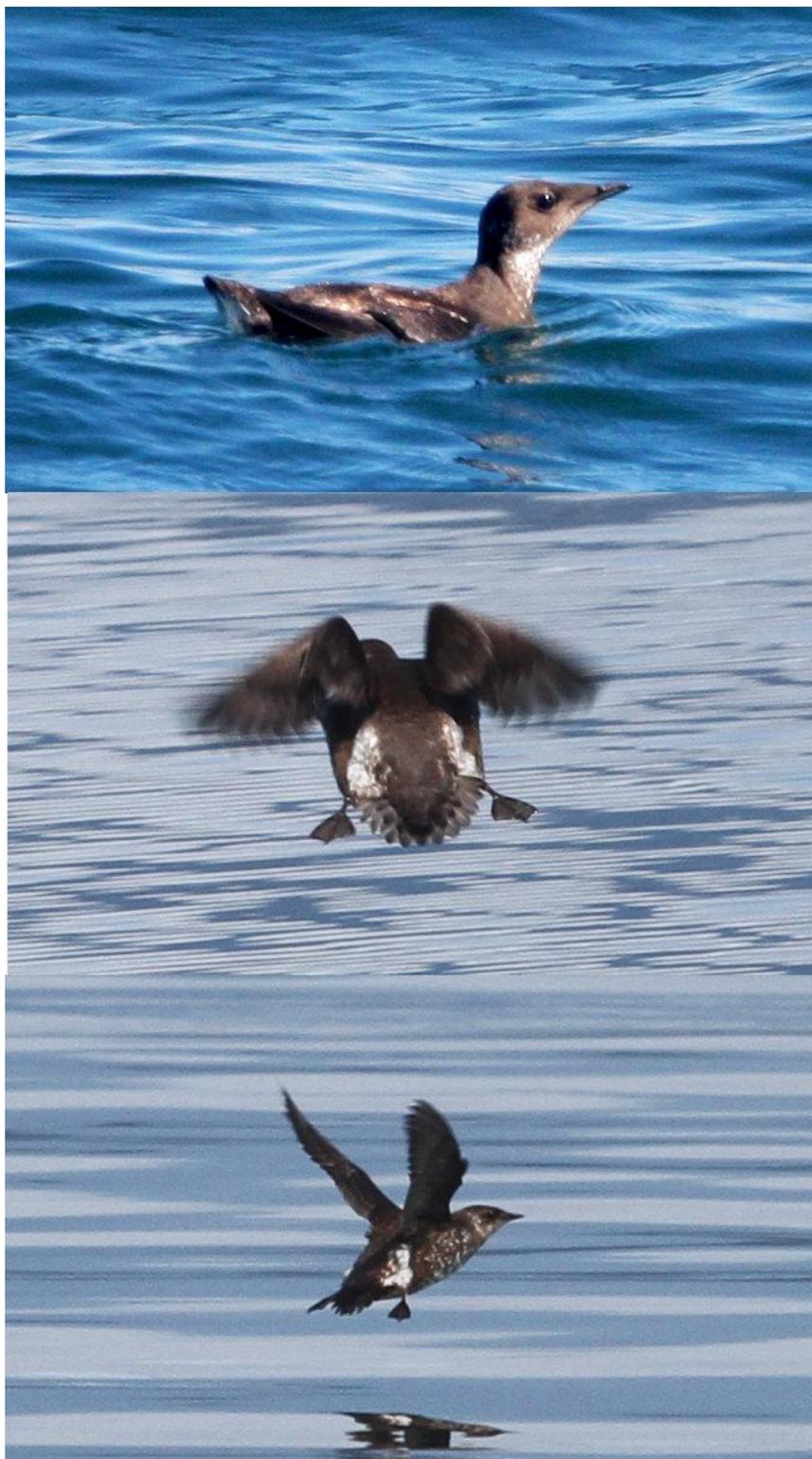


Figure SOP 9.1. Representative photos of MAMU; note longer bill and relatively uniform dark brown color (top; B. Moynahan/NPS photo), white-sided rump but brown outer retrices (middle; C. Sergeant/NPS photo), and speckled but mostly dark underparts/belly (bottom; C. Sergeant/NPS photo).

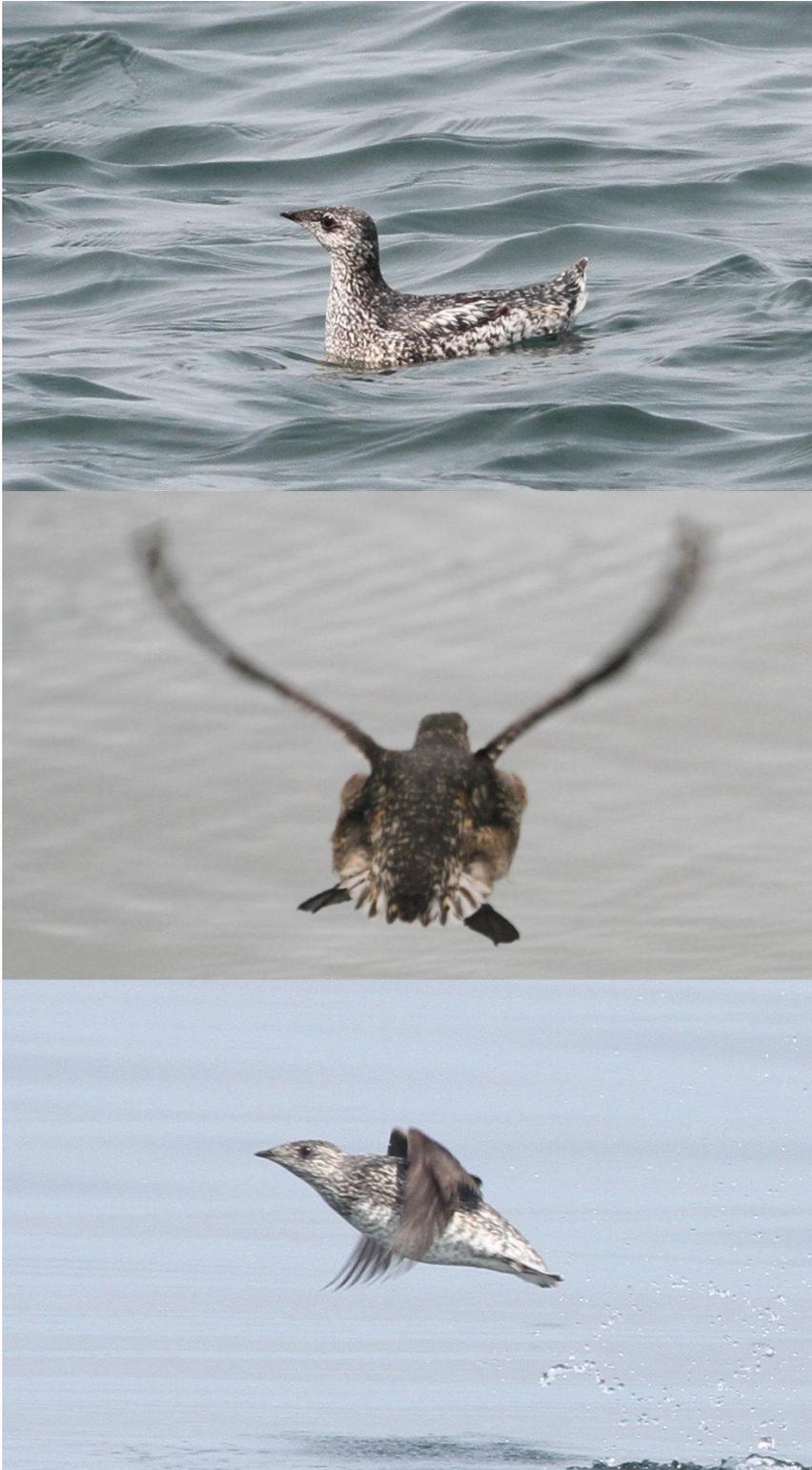


Figure SOP 9.2. Representative photos of KIMU: note short bill, extensive feathering at base of bill, and overall white/grey mottled coloration (top; A. Schaefer/NPS photo), white outer retrices but unusually dark tan/chocolate coloration on back (middle; C. Sergeant/NPS photo), and short feathered bill, mottled white/grey coloration with mostly white belly contrasting with darker wings (bottom; S. Hoekman/NPS photo).

Distance Estimation

Accurate ocular estimation of distance to on-water objects is critical to surveys, and distance estimation calibration procedures consisting of training and assessment ensure Observers develop and maintain proficiency. Accuracy in distance estimation encompasses two conceptual components: bias (average deviation of estimates from truth) and variability (deviations of individual estimates from truth). Minimizing bias is paramount, as it propagates opposite but proportionally similar error in population status (i.e., abundance and density) estimates (Buckland et al. 2001). Unbiased, random variability in distance estimates creates negative bias in population estimates, although for line transect surveys resulting bias often is small and estimation of distances near the transect center line are of primary importance. When the average variability in estimates is $< \frac{1}{2}$ the width of the detection function's "shoulder," resulting bias in population estimates will be minimal ($\leq 3\%$).

For 2010-2012 surveys, width of shoulders for estimated detection functions have ranged from ~60-90 m (Hoekman et al. 2011, 2013a, b), suggesting variability averaging < 30 m will have a negligible effect on population estimates. Based on observations that distance estimates during surveys average ~120 m and that deviations during Observer calibration have been proportional to true distances (NPS unpublished data), we feel that achieving CVs in deviations of ≤ 0.2 will satisfy requirements for minimal bias in population estimates.

Observer performance objective: To minimize bias in population estimates from error in distance estimation, each Observer for a survey year should be trained to estimate on-water distances of ≤ 200 m with an average bias of $\leq 5\%$ and CV of deviations ≤ 0.2 .

Distance estimation calibration requires the following personnel and equipment:

- ≥ 1 Observer(s)
- 1 Boat Pilot
- 1 Session Sergeant (role typically filled by the Data Manager)
- 6-10 calibration buoys (oblong or cylindrical fishing buoys, 8-10" long x ~4" diameter, painted grey, marked with similar colored infrared retro-reflective tape)
- Laser rangefinder
- Dip net
- Distance Calibration-Observer and Distance Calibration-Session Sergeant forms on waterproof paper

Calibration buoys should be neutral in color and should be marked with reflective tape visible above the water line. Ideally, range finders should be able to obtain distance readings in ≤ 10 seconds at ranges ≤ 200 m under all survey environmental conditions.

Distance estimation calibration sessions will consist of variable numbers of trials in which Observers will record estimated distances to calibration buoys and the Session Sergeant will use a rangefinder to record true distances. Sessions can be for either training or assessment. During training sessions, the Session Sergeant will provide immediate feedback on true distances to Observers. No immediate feedback will be provided during assessment sessions, but summarized measures of performance (average and CV of deviations) for each Observer will be provided after each session.

Each session begins by dispersing ~8 calibration buoys on the water in an area of diameter no more than 200 m. The Session Sergeant records data associated with each session on the Distance Calibration Trials: Session Sergeant Record form (initials of Sergeant and Observers, date, start/end times of session, description of training objects (buoys), session type, and environmental conditions). Each Observer records initials, date, session start time, and session type on his/her own Distance Calibration Trials: Observer Record form. See forms in Appendix E. The session start time marks the beginning of dispersal of buoys, while the end time marks when all buoys are retrieved or the session transitions to a different type (e.g., assessment to training).

To begin each trial, the Boat Pilot maneuvers the boat so that most buoys are on one side of the boat at distances of ~20-200 m and then cuts engine power and lets the boat drift with the current. When forward motion of the boat stops, the Session Sergeant indicates the position of the first target buoy. Within 5-10 seconds after all Observers have located the target buoy, the Session Sergeant records the true distance obtained from the rangefinder (to nearest m) and each Observer records their ocular distance estimate (to nearest 10 m) in box 1 for the trial. Each trial continues for up to 9 targets. New trials are initiated by the Sergeant requesting the Boat Pilot to move the boat to a new location, and the session continues until the desired number of trials (explained below) is reached. After the final trial, The Boat Pilot maneuvers the boat to allow buoys to be retrieved using the dip net.

After each session, the Data Recorder uses the Excel spreadsheet "Distance_Calibration.xlsx" stored on the data capture laptop in directory "C:\KIMU\Distance_Estimation\" for data entry and generation of summary statistics. Bias (average deviation of estimated versus true distances) and variability (CV of deviations) for each Observer should be provided to Observers and the Project Leader. Additional summary analyses (e.g., relative to environmental conditions) may also be pertinent to assessing Observer performance. Assessment data will be kept available on the laptop and, after completion of the season, archived to the project area of SEAN's file server as detailed in SOP 3.

Prior to the start of surveys, distance estimation training sessions should be interspersed with other training activities until the Project Leader determines each Observer meets distance calibration accuracy objectives. During this period, the frequency and duration of training sessions are at the discretion of the Project Leader but should reflect experience levels and proficiency of Observers. When developing proficiency of inexperienced Observers, training sessions likely should be at relatively high frequency and duration (i.e., >1 session/day, 6+ trials/session). Once proficiency is demonstrated, it will be essential to maintain proficiency by conducting short training sessions (3-4 trials) on days surveys are conducted. Training sessions should be conducted across the range of environmental conditions experienced during surveys and should allow Observers to develop proficiency in estimation of distances ≤ 200 m. However, the Project Leader may choose to concentrate sessions on specific conditions to ensure proficiency for conditions for which Observers have little experience or substandard performance.

Assessment sessions generally should consist of three or more trials and generally should not immediately follow training sessions. Assessment sessions should begin during the pre-survey period after the Project Leader feels Observers have demonstrated proficiency in distance estimation during training sessions. The Project Leader should assess results in context of meeting Observer performance objectives over the course of each survey year. Because samples for individual assessment sessions will be relatively small, results from

individual sessions are likely to be somewhat variable even if long-term averages meet performance objectives. Generally, individual sessions not exceeding 10% bias and CV of deviations of 0.25 will be within acceptable performance limits, although the Project Leader should consider factors extending across assessment sessions (e.g., have sequential sessions shown poor performance or moderate bias in the same direction?) when deciding if remedial action, such as retraining, is necessary. It should also be noted that average bias will contribute to the CV of deviations. Because bias is critical, it should be addressed first.

All Observers should meet performance limits during at least two assessment sessions under differing environmental conditions prior to commencing surveys. Once surveys have begun, conducting assessment sessions every other survey day is adequate for characterizing Observer performance. If results of assessment sessions fall outside performance limits, the Project Leader can prescribe additional training and assessment sessions as needed to improve and assess performance.

Conditions for assessment sessions ideally should match those during surveys as closely as practical. The distribution of true distances of targets should be typical of the distribution of estimated distances from survey observations (i.e., average = 100-120, SD =40-50). Furthermore, environmental conditions should be representative of those prevailing during the current survey year.

Distance Calibration Data Management

The Excel spreadsheet file "Distance_Calibration.xlsx" in directory "C:\KIMU\ Distance_Estimation\" of the data capture laptop serves to store distance calibration data and provide feedback on Observer performance after each calibration session (Table SOP 9.2). Data are entered, proofed, and stored in Excel tables, and interactive PivotTables immediately generate summary statistics for each Observer, such as the average deviation of estimated versus true distances and the CV of those deviations. Filters and data categories may also be used to generate summaries for specific conditions or comparing factors (e.g., differing environmental conditions, training versus assessment sessions). The instructions below cover basic use and function of this spreadsheet, but native Excel help files will aid users in troubleshooting and exploring advanced functionality of pivot tables.

Detailed Steps

A. Create tables for the current survey year

1. In the "Calibration Draft.xlsx" file, right-click the 'Template' tab, select 'Copy', and rename the new tab with the current survey year.
2. On the current year tab, left-click within the Excel table (with the blue column headers) containing the sample data.
3. Rename the table "Tableyy" where yy is the last 2 digits of the survey year, by selecting 'Design' under 'Table Tools' in the ribbon bar and entering the name in the box under 'Table Name'.
4. In the Excel table, double left-click on the column headers with the "Obs1" to "Obs3" and rename as needed with the initials of survey Observers.
5. Left-click within the PivotTable (with the red column headers) and select 'Options' under 'PivotTable Tools' in the ribbon bar.
6. In the 'Data' box, select 'Change Data Source' and enter the name of the Excel table from 1.3 above.

7. Double left-click on the column headers of the PivotTable to replace 'Obs1' to 'Obs3' with initials of survey Observers.
8. Delete or replace the black sample data in the Excel table. The gray-shaded text under the gray header bar should typically not be altered unless changes are needed to the table structure or function (e.g., adding additional Observers).

B. Entering data after each session

1. Data should be entered immediately after each calibration session, typically by the Data Recorder.
2. The Excel table should contain one row for each distance recorded on the Session Sergeant record.
3. If sufficient rows are not available in the table, create additional rows by left-clicking and dragging down the bottom-right corner of the table. Gray text on the right-hand side of the table should propagate down the new rows.
4. Begin each session by entering the metadata from the Session Sergeant record in the first unoccupied row beneath existing data.
5. Beginning with this row, enter each combination of Trial #, Target #, and true distance on subsequent rows.
6. When reaching the end of the data for the Session Sergeant record, metadata from step 2.4 may be copied to all corresponding rows for the session.
7. For each Observer record, enter the estimated distances in the column corresponding to the Observer's initials by matching the Date, session Start Time, Trial #, and Target # with those already entered for the Session Sergeant record.
8. If distance estimates are missing for an Observer, leave corresponding cells blank in the Excel table.
9. Data entered in the Excel table should be proofed against the original data after entering each record.

C. Data summary

1. After making changes to the Excel table or the PivotTable, the PivotTable must be refreshed (sometimes twice) to reflect changes. Refresh by left-clicking within the table, select 'Options' under 'PivotTable Tools' in the ribbon bar, and then 'Refresh' in the Data box.
2. Because true distances to individual targets may be longer than ranges that Observers are trained and assessed, it may be useful to filter data to be used in the PivotTable. All records with true distances greater than the distance specified in the purple filter box above the upper-left corner of the Excel table will be censored from Pivot Table summaries.
3. As initially set up, the PivotTable displays from left to right the average true distance to targets, the average deviation of estimated versus true distances for each Observer, the CV of deviations for each Observer, and the SD of deviations for each Observer.
4. Categories for data display are shown in the column under the 'Row Labels' header. The initial setup displays these summary statistics by survey day, and the 'Grand Total' row provide overall statistics.
5. The data filter, set to the 'Training' field, is displayed above the PivotTable. Left-clicking on the drop-down menu will allow display of statistics for training sessions ('Y'), assessment sessions ('N'), or all data ('All').

6. The PivotTable is interactive: left-click within the PivotTable to bring up the 'PivotTable Field List'. If this is not visible, select 'Options' under 'PivotTable Tools' in the ribbon bar, and make sure 'Field List' is selected in the 'Show' box.
7. Categories for comparing statistics may be added to or removed from the PivotTable by dragging the desired fields into or out of the 'Row Labels' box. For example, removing 'Date' and adding 'Beaufort' would show statistics for each Beaufort category recorded in the data.
8. Similarly, desired fields for filtering data may be added or removed from the 'Report Filter' box.
9. Remember that the PivotTable will not update until it is 'refreshed'.

Table SOP 9.2. Fields in spreadsheet file "Distance_Calibration.xlsx".

Field	Type	Description
Excel table		
Year	integer	4-digit survey year
Sergeant	string	Initials of Session Sergeant
Date	date	Date (<i>mm/dd/yyyy</i>)
Start time	time	Start time of session (24:00)
End time	time	End time of session (24:00)
Training	string(1)	Y N indicator for whether data are for a training session
Trial	integer	Number of trial within session
Target	integer	Number of buoy target during Trial
Distance	integer	True distance from rangefinder
Obs1	string	Placeholder for initials of Observer(s)
Beaufort	integer	Beaufort Scale for sea state. 0: Calm <1 km/h; 0 cm, Glossy 1: Light air 1-3 km/h; 0-20 cm, Ripples 2: Light breeze 3-7 km/h; 20-50 cm, Few whitecaps 3: Gentle breeze 8-12 km/h; 50-100 cm, Scattered whitecaps
Weather	integer	Weather conditions. 0: <50% Cloud cover, 1: >50% Cloud cover, 2: Fog, 3: Mist – Light rain, 4: Moderate – Heavy rain
Visibility	integer	Code for seeing distance in meters. 1: >500 m, 2: 250-500 m, 3: <250 m
Buoys	string	Brief description of survey buoys (size, color, etc.)
Notes	string	Additional relevant information
PivotTable		
Row Labels	numeric	Field(s) used to categorize summaries
Avg{Distance}	numeric	Average true distance
Avg{dObs1}	numeric	Average deviation (estimated – true distances) for Observers
CV{Obs1}	numeric	CV of deviations (SD{deviations}/{average true distance}) for Observers
Avg{dist1}	numeric	Average estimated distance for Observers
SD{dObs1}	numeric	SD of deviations (SD{estimated – true distances) for Observers

Survey Observations

From the bow observation deck, Observers locate groups (associations of same-species murrelets separated by <~5 m) and transmit records to the Data Recorder via a park radio. Section 3 of SOP 1 details the manner in which observations are reported. In most conditions, it is best to hold the radio 1–2 inches from one's

mouth while speaking in a regular tone. Confirm with the Data Recorder that your voice is coming through clearly. As detailed in SOP 1, data is transferred to the Data Recorder in the following order:

1. "Record" (notifies Data Recorder of incoming record and serves as a sacrificial word in the event of a cut transmission, so critical data are fully transmitted after the first word)
2. Angle to observed group
3. Distance to observed group
4. Group size
5. Species class (K – Kittlitz's, M – marbled, U – unidentified *Brachyramphus* murrelet)

Two examples of observation transmissions are:

1. "Record, one-three-zero degrees, nine-zero meters, 2, K"
2. "Record, one-eight-four degrees, two-zero meters, 1, K, and, 2, M"

Note that in the second transmission, both two species classes were observed at the same location and reported in the same record.

Distance and angle to the observed group should be estimated simultaneously. Ideally, estimates should fix the group's initial location, although this may not always be possible (e.g., because of high density of groups, because groups dive before estimate are obtained, etc.). Distance is an ocular estimate to the nearest 10 m. Observation angle is determined by an angle board mounted on the bow between observers. Once a group is spotted, the angle is measured as soon as possible by pointing the angle indicator in the direction of the group and reading the resulting angle from the board. Dead ahead of the boat is 180°; angles <10° from the center line (171-189°) should be estimated to nearest 1°, all others to the nearest 5°.

Safety in the Field

SEAN abides by the safety policies set forth by GLBA management. These policies describe the necessary Personal Protective Equipment (PPE) for various field conditions and requirements for boat-based surveys. These safety considerations are touched upon in the protocol narrative and reiterated here. This is not considered an exhaustive safety discussion but is meant for SEAN field employees to be aware of what GLBA safety requirements must be understood and abided by before working in the field. Since safety protocols continually evolve, we remind new survey team members that each person is responsible for learning what training is necessary before field work may begin.

Generally, each onboard member of the KIMU survey team must be familiar with the safety features of the research vessel. For the *R/V Fog Lark*, these safety features include emergency position-indication radio beacons (EPIRBs), personal flotation devices (PFDs), immersion suits, park and very high frequency (VHF) radio, radar, fire extinguishers, first-aid kit, and chart plotter/depth sounder.

Boat Pilots operating the *Fog Lark* must complete the full one-week Department of the Interior Marine Operator Certification Course (DOI-MOCC), and attend one-day refresher courses every two years. In addition, Boat Pilots must be certified by GLBA staff (typically protection rangers and/or Coast Guard certified captains) to operate specific vessels. This certification process includes knowledge testing of boating etiquette and safety, and skills testing of driving and mooring.

Before the start of a field day, Boat Pilots must ensure that each survey team member is well-versed in the safety features of the vessel and understands how to act in an emergency, including situations such as what to do in the case of a person overboard.

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SOP 10: Protocol Revision (KM_H creation)

Version 1.0

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
	November 2012	S. Hoekman, W. Johnson, B. Moynahan, C. Sergeant	Initial version		1.0

Summary

Periodically, material changes must be made to the protocol to take advantage of new or different technologies, equipment, and methods. Changes may also be made to correct significant errors in the document or to refine and update the data reports.

The Program Manager, Project Leader, and Data Manager jointly build a list of desired changes. They review the issues, accept some or all of them by consensus, and draft new language to affect the accepted changes. One person shall be chosen to coordinate the new document and be responsible for the new draft. Changes to key items will trigger an external review of the draft document. Reviews will consider impacts including but not limited to those caused by changes in equipment, data collection methods, and data processing methods.

After satisfying both internal and external reviewers, the updated protocol will go through formal validation and certification by the Program Manager and Data Manager. The certified protocol will be widely disseminated.

Detailed Steps

A. Program Manager (PM) Tasks

1. Periodically poll Project Leader (PL) and Data Manager (DM) on the need for a protocol revision cycle.
2. Schedule a revision cycle when called for by consensus.
3. Obtain a new formal protocol ID number from Data Manager.
 - a. Method for assigning a protocol ID is formally set in SEAN's Data Management Plan SOP-602 Version Control.
 - b. A new ID is required for each revision because most data collected are tagged with the specific protocol they were created under: the mechanism is rigid.
4. Solicit agenda of issues to address.
5. Initiate kick-off meeting.

B. Program Manager, Project Leader, and Data Manager Tasks

1. Prepare issues lists.
2. Agree on overall scope of revision.
 - a. "Minor" will have internal review.

- b. "Major" will have peer review.
3. Agree on a "coordinator" who is responsible for managing assembly of the revised document.
4. Obtain the most recent Word version of the current protocol from the DM to serve as the basis for the new document.
 - a. The original DOCX file is copied to an editable destination file.
 - b. The document is set for tracked changes.
 - c. A global search and replace is done to change all existing references to the protocol ID to the new designator.
 - d. The DM provides a link allowing access of the DOCX file by the three team members through a browser.
 - e. The actual final product will be made available on the web only as read-only PDF in order to minimize the chance of multiple conflicting documents being built.
5. Draft possible revisions.
 - a. Each team member should take responsibility for sections within their realm of expertise.
 - b. If a particular section needs to be addressed to meet multiple needs, it should be worked on serially.
 - i. Get team agreement on the order of attack for issues.
 - ii. Assign person to do first revision covering first issue.
 - iii. Obtain consensus on the first revision.
 - iv. Assign person to do second revision covering second issue, etc.

C. "Coordinator" Tasks

1. Assemble revision drafts into a coherent document.
2. Maintain a document change table in the SOP document to track internal versioning.
3. Distribute to PM, PL, and DM for internal review.
4. Update document to satisfy internal review.
5. Obtain consensus of PM, PL, and DM.
6. Format the document.
7. If scope is major, coordinate external review.
 - a. Pass document to Regional I&M Coordinator for consideration.
 - b. Distribute resulting review comments to PM, PL, and DM.
 - c. Revise protocol in light of review comments.
 - d. Coordinate revisions among team.
8. Assemble document.
9. Obtain final team approval.
10. Format document as a Natural Resource Report (NRR).
 - a. Coordinate technical/formatting NRR review
 - b. Obtain a "TIC" document number from NRPC.
 - c. Make final technical revisions.
11. Notify team of completion.

D. Program Manager Tasks

1. Generate a PDF file from the original Word document.

2. Submit both the PDF and DOCX files via email attachment to the Data Manager for validation.
 - a. Specify in the message body it is deliverable KM_H, as defined in protocol KM_2012.1.

E. Data Manager Tasks

1. On receipt of the submission, assign the next formal Submission Number to this file, as found in the master Submission_Log table.
 - a. Use the "Update Submission Log" web tool at http://165.83.57.239/0_submission_update.aspx .
 - b. Complete Submission_Log details up through the Submission_Date column.
2. Save the attached file into the staging area for validation at \\inplbafs03\data\SEAN_Data\Staging\KM\KM_H .
3. Validate the two files according to current criteria.
4. Record validation summary data in the Submission_Log using the web tool.
5. If submission fails mandatory criteria, reply with a "failure email" that includes:
 - a. The submission number assigned
 - b. The deliverable ID
 - c. The protocol ID
 - d. Documentation listing all the specific mandatory criteria failed
6. If submission passes mandatory criteria, reply with a "success email" that includes:
 - a. The submission number assigned
 - b. The deliverable ID
 - c. The protocol ID
 - d. Documentation listing any specific optional criteria failed
 - e. Request to certify deliverable as complete

F. Program Manager Tasks

1. On receipt of a failure email:
 - a. Make corrections so the deliverable meets mandatory criteria.
 - b. Make another submission with the corrected deliverable candidate
2. On receipt of a success email, review any failed optional criteria:
 - a. If these are acceptable to PM, PL, and DM:
 - i. Reply with a "certification email" stating the deliverable is certified and may be disseminated.
 - b. If these are unacceptable:
 - i. Reply with a "withdrawal email", stating the deliverable is withdrawn.
 - ii. Take remedial action to obtain a corrected deliverable.
 - iii. Restart the process from the beginning.

G. Data Manager Tasks

1. On receipt of a withdrawal email:
 - a. Mark the withdrawal in the Submission_Log's Status column using the web tool.
 - b. Terminate the process.
2. On receipt of a certification email:
 - a. Due to the nature of these data NO sensitive information is in the deliverable.

- b. Copy the two submitted files to test environment at AUXREP\KM\KM_H\
 - i. Name them <protocol_ID>.PDF and <protocol_ID>.DOCX.
- c. Create web page link to the new PDF but not the .DOCX, which remains hidden.
- d. Retire the old protocol so it becomes accessible from the Historical Protocol link.
- e. Mark the certification in the Status column in Submission_Log using the web tool.
- f. Using a database editing tool such as SSMS, insert the new protocol ID into the Staging database table SEAN.TBL_PROTOCOL.
- g. Propagate from test to production environment.
- h. Update the annual deliverable tracking spreadsheet showing date of completion for KM_H.
 - i. Record in the tracking spreadsheet for the year reflected in the protocol_ID, which may not be the current year.
 - ii. An entirely new row will need to be added to the sheet, as this is not a scheduled deliverable already accounted for.
- i. Submit the final document to NRInfo Portal.
- j. Update the I&M protocol database to reference the new protocol.
- k. Revise web sites to accommodate any altered information structure set in the new protocol.
- l. Update the scope of the formal metadata so it includes the new date and versioning information.

SOP 11: Detection Function Estimation (KM_J Creation)

Version 1.0

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
	November 2012	S. Hoekman, W. Johnson, B. Moynahan, C. Sergeant	Initial version		1.0

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Summary

After certification of the “KM_E: Cumulative observation database”, the current year’s survey data are used to estimate a detection function, which provides estimates of detection probability for murrelet groups relative to their perpendicular distance from the transect center line. This detection function is integral to assessing whether critical assumptions of methods were met and to population estimates. Analyses are conducted using Program DISTANCE. Exploratory analyses identify violations of assumptions and potential remedies and also identify appropriate truncation and binning strategies for data. Statistical criteria and biological considerations are used to select an appropriate structure for the detection function. Estimates of group size for each species class may also be produced in and exported from DISTANCE. The Data Manager produces necessary input files for DISTANCE analyses, imports data to DISTANCE, and imports to KM_J: Detection function the output from DISTANCE analyses. The Project Leader will conduct analyses to estimate a detection function and group sizes and export results from DISTANCE.

This protocol employs Program DISTANCE version 6.0 release 2 (Thomas et al. 2010), which is Windows-compatible software freely available at <http://www.ruwpa.st-and.ac.uk/distance/>. Because results and file structures may differ among versions, we recommend use of this version to ensure compatibility with database structure. Additional to information below and help files accessed by pressing <F1> within DISTANCE, extensive documentation is provided in an PDF file in the DISTANCE install package. Furthermore, two texts on distance sampling provide extensive theory and practical examples of estimation and use of detection functions (Buckland et al. 2001, 2004), and we will make reference to specific, short passages in external sources to augment methods and discussion in this document.

Program R and Program TINN-R are also used to create figures from DISTANCE output. Program R is a software language and statistical computing environment that is freely available at <http://www.r-project.org/>. Program TINN-R is a GUI/Editor for the R programming language. Information about this software is available at <http://www.sciviews.org/Tinn-R/>, and software is freely available at <http://sourceforge.net/projects/tinn-r/>. This protocol provides R code that can be easily executed within TINN-R to produce specified graphic output.

Outputs from this SOP are: 1) a right-truncation distance for censoring murrelet groups based on distance from the transect center line, 2) an estimated detection function and associated parameter estimates, 3) a figure of the estimated detection function, 4) an estimated detection probability for groups within the right-truncation distance, 5) estimated effective strip width, and 6) estimated group size for each species class (produced separately for analyses of population status and trend).

This SOP will be completed by executing these steps:

1. Importing data into DISTANCE
2. Exploratory analyses to prepare for subsequent analyses
3. Selection of a detection function and estimation of parameters
4. Estimation of group size
5. Exporting results from DISTANCE

Throughout the detailed steps below (numbered text), black text indicates actions essential to the SOP. However, successfully completing these tasks will require the Project Leader to apply judgment to avoid

potential pitfalls. We have used **blue text** to indicate information guiding such decisions, including definition of key terms and concepts, advice for identifying and remedying problems, and references to supporting material.

Data Import to DISTANCE

Necessary data from the repository will be imported to a DISTANCE project via a formatted text input file. A DISTANCE project template will import appropriate settings, data structure, and preliminary analyses. The “KM_E: Cumulative observation database” repository deliverable must be certified before data may be imported.

Detailed Steps

A. Data Manager Tasks

1. Create a new directory to hold the year's work named [“\\inpglbafs03\data\SEAN_data\Work_zone\KM\KM_J\yyyy”](#) where yyyy is the four-digit year.
2. Create the ‘DFplot.r’ file to be used in plotting the detection function
 - a. ‘DFplot.r’ is an unformatted text file containing Program R code that can be used to create an image file containing a plot of the detection function.
 - b. Copy the DFPlot.r file into the new directory from ... \KM\KM_J\.
 - c. Edit DFPlot.r so its filenames and paths for output table and plot reflect the survey year.
 - d. In the event a previous copy of DFPlot.r is not available, the file can be recreated using a text editor to open a new text document, copying the text from the Appendix into the file, and saving the unformatted text under the file name ‘DFplot.r’.
3. Produce a comma-delimited text file of murrelet observation data for import into DISTANCE
 - a. Connect to the data management web site (currently \\165.83.57.239) and log in using your Windows userid and password – userid must be of the form “username@NPS”.
 - b. Under Kittlitz's Murrelets, click on the KM_J task called “Create input table SOP11.1”.
 - c. Specify the year of interest from the dropdown.
 - d. View the sample result on screen if desired.
 - e. Press the button to save complete results to [“\\inpglbafs03\data\SEAN_data\Work_zone\KM\KM_J\yyyy\input_yyyy.txt”](#) where yyyy is the four-digit survey year.
 - f. The generated file will have these characteristics:
 - i. Each observation of a murrelet group with complete distance and angle data will occupy one row in the file.
 - ii. The file contains eight columns in the order specified in Table SOP 11.1. Columns contain headers for field names as specified in Table SOP 11.1.
 - iii. The angle field in column 5 is adjusted before import to DISTANCE.
 1. The source Angle field in Tbl_observation ranges from 0-360°, increasing from 0° opposite the direction of travel on the transect path.

2. In DISTANCE, permissible angle values range from 0-180°, increasing with deviation from the direction of travel on the transect path.
3. Angle values from Tbl_observation is adjusted as:
 - i. Range 180-360°, subtract 180°
 - ii. Range 0-179°, subtract from 180°
- iv. The file is sorted in ascending order by the 'Transect' field.
4. Create a new DISTANCE project for the survey year
 - a. A template file is used to define settings, data structure, and pre-defined analyses for the DISTANCE project for each survey year.
 - i. There should be both a template.dst file as well as a template.dat directory in \\inpglbafs03\data\SEAN_data\Work_zone\KM\KM_J\template.
 - ii. Copy them both to the current 'yyyy' directory.
 - b. If no template project file set is available, define a template from scratch.
 - i. Create the base project files.
 1. Start Program DISTANCE and use the New Project Setup Wizard to name the file "template.dst" (Figure SOP 11.1).
 2. Proceed through successive steps of the New Project Setup Wizard, specifying settings as shown in Figure SOP 11.2. Click 'Finish' to start the Import Data Wizard.
 - ii. Populate the base project with observation data.
 1. Select a properly formatted text file (as in section 1.1 above) containing observation data Figure SOP 11.3.1.
 2. Proceed through successive steps of the Import Data Wizard, specifying the data structure as in Figure SOP 11.3.2-6.
 3. Finishing the Import Data Wizard will create the project template file and open the 'Data' tab of the 'Project Browser'. Left click on the 'Observation' data layer to confirm that the data have been properly imported.
 - iii. Specify pre-defined analysis components.
 1. Start DISTANCE and load the project template file created above.
 2. Open the 'Analysis Components' window to view the Data Filters (Figure SOP 11.4). Rename the Default Data Filter to "Untruncated" and open the 'Item Properties' window for this data filter.
 3. Select each of the tabs in the 'Item Properties' window, ensure settings match those shown in Figure SOP 11.5, and close the window.
 4. Copy the "Untruncated" data filter to create 2 new filters named "Truncated" and "Truncated Bins A", and open the 'Item Properties' windows to apply settings to each as shown in Figure SOP 11.6.1-3.
 5. Copy the "Truncated Bins A" filter create the filter "Truncated Bins A Status". Open the 'Data Selection' tab in the 'Data Filter

Properties' window (Figure SOP 11.6.4), and in the data selection box use the drop down menu to select the 'Sample' layer type.

6. In the text box to the right, enter the text inside the brackets: [Label <> '016']. This creates a data filter that excludes Transect 016 when estimating group size for analyses of population status.
 7. From the 'Analysis Components' window, left-click the model definitions button to list the Model Definitions (Figure SOP 11.7.1). Rename the default model definition to '4 models AIC-selected' and open the 'Model Definition Properties' window by right-clicking on the ID number and selecting 'Item Properties'.
 8. Successively select each tab near the top of the 'Model Definition Properties' window and apply settings as shown in Figure SOP 11.7.2-6 and Figure SOP 11.8. Note that the 'Detection Function' tab has 5 separate lower level tabs, with settings shown in Figure SOP 11.9.
 9. From the 'Model Definitions' window, create a new model definition named 'Top model export stats' as shown in Figure SOP 11.9. Open the "Model Definitions Properties" window, select the 'Misc.' tab, check the 'Create results stats file' box, and enter the output path \\inpglbafs03\data\SEAN_data\Work_zone\KM\KM_J\yyyy\DFstats_yyyy.txt.
 10. Right-click on the '4 models AIC-selected' definition and create an additional 4 model definitions with names corresponding to the model definitions in four rows in Table 11.2 after the "Top model export stats" definition. For each, navigate to the 'Models' lower-level tab in the 'Detection function' tab of the 'Model Definition Properties' window (see Figure SOP 11.8.1), and use the "-- button to the right of the 'Detection function models' box to reduce the number of models to 1. Then, select the appropriate key function and series expansion for each using the drop down menus.
 11. Create 2 additional model definitions by copying '4 models AIC-selected' definition corresponding to the next 2 model definitions in Table 11.2 with only key functions. For each, reduce the number of models to one and select the appropriate key function in the 'Models' lower-level tab of the 'Detection function' tab in the 'Model Definition Properties' window (Figure SOP 11.8.1). In the 'Adjustment terms' lower-level tab, reduce the 'Maximum terms' to '0' using the down arrow button. (Figure SOP 11.8.2).
- iv. Specify pre-defined analysis sets and analyses.
1. Navigate to the 'Project Browser' using 'View|Project Browser' in the menu bar.
 2. As shown in Figure SOP 11.10.1, select the 'Analyses' tab and then rename the analysis set "Exploratory".

3. Create a total of 3 models in the 'Exploratory' set, and rename each as shown in Figure SOP 11.10.1.
 4. Open the 'Analysis Details' window for each analysis and define the 'data filter' and 'model definition' (Figure SOP 11.10.1-2) as listed in Table SOP 11.2.
 5. As shown in Figure SOP 11.10.3, use the drop down menu to select a new analysis set and rename it "Estimation". Create a total of 9 analyses in this set and name as in Figure SOP 11.10.4.
 6. Open the 'Analysis Details' window for each analysis and define the 'data filter' and 'model definitions' as listed in Table SOP 11.2.
 7. The project template file is saved automatically; save on exiting from DISTANCE is not needed.
- c. Import survey observation data to a Program DISTANCE project file.
- i. Start Program DISTANCE and use the New Project Setup Wizard to create a new project named "DF_yyyy.dst", where yyyy is the survey year (Figure SOP 11.11.1).
 - ii. In successive steps of the New Project Setup Wizard (Figure SOP 11.11.2-4), specify the project template file that will be used to import settings and preliminary analyses, and then proceed to the 'Data Import Wizard'.
 - iii. To begin the 'Data Import Wizard', select the formatted text input file ("input_yyyy.txt" created above) for the current year's survey (Figure SOP 11.12.1).
 - iv. Proceed through successive steps of the Import Data Wizard, specifying the data structure as in Figure SOP 11.12.2-5.
 - v. Finishing the 'Import Data Wizard' will create the project file and open the 'Data' tab of the 'Project Browser'. Left click on the 'Observation' data layer to confirm that the data have been properly imported (Figure SOP 11.12.6).
 - vi. The project file is saved automatically; save on exiting from DISTANCE is not needed.

Exploratory Analyses

The purpose of analyses in this SOP is to estimate an appropriate detection function for the current year's survey observations using DISTANCE. The detection function is a curve describing the probability of detection of murrelet groups during surveys relative to perpendicular distance from the transect center line. Several alternative 'key functions' may be used to model the detection function, and several alternative 'series expansion terms' may also be added to these key functions. The ultimate goal of analyses is to select an appropriate model for estimation of the detection function, but exploratory analyses are necessary to lay the groundwork for further analyses.

The Project Leader will create a DISTANCE project file to conduct exploratory analyses of the current year's survey data. Data is imported to DISTANCE using a project template file, which will provide appropriate settings and pre-defined analyses. These analyses will serve as a starting point for visualizing data, estimating preliminary detection functions, and assessing adherence of data to assumptions of statistical

methods. Based on results, the Project Leader will define additional analyses as needed. The Project Leader will apply statistical criteria and judgment to select an appropriate right-truncation distance for censoring observations and appropriate bins for grouping observations by distance. When necessary, suitable remedies will be applied to mitigate problems arising from violations of assumptions.

Detailed Steps

A. Project Leader Tasks

1. Execute preliminary models to visualize data
 - a. In DISTANCE, open the project file for the current year's survey data, navigate to the 'Project Browser', and select the 'Exploratory' analysis set to view the pre-defined exploratory analyses (Figure SOP 11.13.1).
 - b. Pre-defined analyses: The 5 pre-defined analyses are listed in Table SOP 11.2. These analyses primarily differ in how data are truncated and binned.
 - c. Alternative models: All predefined analyses consider 4 alternative models for estimating the detection function, and these models consist of a 'key function' paired with a 'series expansion'. Alternative models are the 'half-normal' key function paired with the 'hermite polynomial' or 'cosine' series expansion and the 'hazard' key function paired with the 'simple polynomial' or 'cosine' series expansion.
 - d. Akaike's Information Criterion (AIC; Burnham and Anderson 2002): In each analysis, the model with the lowest AIC value indicates the most parsimonious model, which adequately explains the data with the minimum number of parameters. Parameter estimates and figures for each analysis are from this "best" model only.
 - e. Select the 'Untruncated' analysis by left-clicking on it and then left-click the 'Run' button to execute this analysis (Figure SOP 11.13.1). This analysis includes all observations of murrelet groups and uses exact distance data.
 - f. Open the 'Analysis Details' window and select the 'Results' tab. Use the 'Back' and 'Next' buttons or the drop down menu to page through results to locate the 'Detection Fct/Global/Plot: Detection Probability 1' and 'Detection Fct/Global/Plot: Detection Probability 2' windows (Figure SOP 11.13.2), which show the distance data displayed in histograms with differing interval width.
 - g. The 'Log' tab: Selecting this tab will provide specifications for this analysis as well as any warnings (yellow/orange) or errors (red). Warnings are common and usually do not indicate serious problems, but errors require resolution. Descriptions of warnings and errors are found in the appendix of the DISTANCE documentation.
 - h. Detection Probability Plot: The estimated detection function from the AIC-selected model is shown in red; probability of detection of murrelet groups (y-axis) is shown relative to perpendicular distance in meters from the transect center line. The blue histogram shows the frequency of detections at different distances from the center line; the frequencies are scaled to match the scale of the detection function. The histogram serves to visualize the raw data.
2. Select a right-truncation distance

- a. Using the 'Detection Probability' plots from the "Untruncated" analysis, select the perpendicular distance from the transect center line (in 10's of meters) beyond which the probability of detection is less than ~0.15.
 - b. Right-truncation distance: This is the perpendicular distance from the transect center line beyond which all observations are censored. Observations become rare and uneven at large distances, which can create problems for estimating a detection function. Therefore, right-truncation typically is applied where data become sparse. For additional discussion, see section 4.3 of Buckland et al. (2001).
 - c. Selecting the right-truncation distance requires judgment and should be based on the overall trend of declining detection probability, not just local variation. An estimated detection function may provide a useful guide if it adequately fits the data. As an example, for the data presented in Figure SOP 11.13.2, observations were right-truncated at distances >230 m.
 - d. The selected right-truncation distance should be applied to all future analyses by editing the 'Data Filters' pre-defined and user-defined analyses. In the 'Analysis Components' window open the 'Data Filters' window (Figure SOP 11.14.1). For the 'Truncated', 'Truncated Bins A', and 'Truncated Bins A Status' analyses, open the 'Data Filter Properties' window and select the 'Truncation' tab (Figure SOP 11.14.2). Select 'Discard all observations beyond' and then enter the selected right-truncation distance. When prompted, confirm the change by selecting 'Yes' in the pop-up window.
3. Consider binning observations based on distance
- a. Shape criterion: To meet statistical assumptions, the detection function should 1) be monotonically and smoothly declining, 2) should asymptotically approach zero at larger distances, and 3) should have a "shoulder," meaning that the detection function should be relatively flat (slope ~0) at small distances.
 - b. Purpose of binning data: Binning data (i.e., grouping observations based on intervals of perpendicular distances) may be useful in improving the robustness of estimates by improving adherence to shape criterion.
 - i. Selection of bins: Typically, data can be grouped in 7-10 bins with little loss in precision of estimates relative to analyses using exact distances. Selection of "cut-points" for bins depends on distribution problems observed in the data (below), but selection of the first cut-point >0 is critical. Selection of bins is likely to be an iterative process. Exploratory visualization of the data will identify problems, and several alternative binning strategies may be considered. Fitting detection functions to the data may also reveal poor goodness-of-fit and motivate further investigation of binning strategies.
 - ii. Heaping: "Heaping" occurs when the frequency of observations at specific distances is inflated relative to frequencies at nearby distances. Heaping often results from systematic errors by observers during data acquisition. For example, in estimation of distances and angles to murrelet groups, observers might favor "convenient" values (e.g., distances of 50 or 100 m, angles of 0° or 45° relative to the path of the boat), which can result in peaks and troughs

- in detection frequencies (Figure SOP 11.15.A). Placing binning cut-points at mid-points between peaks can improve adherence to the shape criterion and improve the fit of the detection function to the data (Figure SOP 11.15.B). Overuse of the 0° angle can result in a spike in observations on the transect center line (see Thomas et al. 2010 Figure 2a). In such case, the width of the first bin should be sufficient to smooth the spike by averaging out local peaks and troughs.
- iii. Movement prior to detection: Distance sampling assumes animals are detected at their initial locations. If animals near the transect center line attempt to evade by moving away from the boat, there may be a dearth of observations at short distances and a surplus of observations at intermediate distances (Figure SOP 11.16.A). If the magnitude of evasive movement is not too large, this problem may be mitigated by increasing the width of the first bin to include most groups that are moving away from the transect center line (Figure SOP 11.16.B).
 - iv. (Over-) Guarding the center line: If observers devote too much attention to searching near the center line relative to waters slightly further away, then detection probability may decline steeply at intermediate distances (see Figure 2.1 in Buckland et al. 2001) and hence violate shape criteria. Having observers distribute search effort over a wider area can resolve this problem.
 - v. Abrupt changes in frequencies of detections violate shape criteria and hamper achieving adequate goodness-of-fit for detection functions. Bins that straddle such changes will make changes more gradual.
- c. In DISTANCE, select the 'Analyses' tab in the 'Project Browser' and navigate to the 'Exploratory' analysis set (Figure SOP 11.17.1). Select the 'Truncated' analysis and execute it.
 - d. Open the 'Analysis Details' window of the 'Truncated' analysis and select the 'Results' tab. Use the 'Back' and 'Next' buttons or the drop down menu to page through results to locate the 'Plot: Detection Probability 1' and 'Plot: Detection Probability 2' windows (Figure SOP 11.17.2).
 - e. Use the histograms and estimated detection functions to identify any distribution problems. If none are present, then binning is not required and you may proceed to "Selecting a Detection Function" and conduct analyses using exact instead of binned distances values. However, binning is typically useful.
 - f. The example histogram in Figure SOP 11.17.2 shows some evidence of evasive movement and 'heaping.' Evasive movement appears slight, with a peak in observations at ~15 m. The heaping at ~120 m likely reflects high usage of the 150 m distance estimate by observers in combination with typical angular deviation of ~25° from the center line.
 - g. If binning is justified, open the 'Analysis Components' window, select the 'Data Filters' tab, and open the 'Data Filter Properties' window for the 'Truncated Bins A' filter (Figure SOP 11.17.3).

- h. The 'Intervals' tab will show a pre-defined number of bins and cut-points (Figure SOP 11.17.4); adjust as needed.
- i. Navigate to the 'Analyses' tab of the 'Project Browser' to select and execute the 'Truncated with Bins A' analysis. Open the 'Analysis Details' window and the 'Results' tab, and navigate to the 'Plot: Detection probability' window to view a histogram using the defined bins.
- j. The example histogram in Figure SOP 11.17.5 shows how binning has minimized problems seen in 11.17.2. The 0-30 m bin has 'leveled' the peak associated with evasive movement, and placing a cut-point at 120 m near the peak of the 'heaped' observations has distributed the excess observations into adjacent bins and 'smoothed out' the peak.
- k. It may be useful to consider alternative binning strategies. If so, create new 'data filters' and 'analyses' to visualize alternatives. In the 'Data Filters' tab of the 'Analysis Components window, right-clicking on an existing data filter and selecting 'New Item' will copy existing settings to a new data filter, which can be renamed (e.g., 'Truncated Bins B', etc.) by double-clicking on the data filter name. Follow procedures in Figure SOP 11.17.3-4 to define bins. In the 'Analyses' tab of the 'Project Browser,' right-clicking on an existing analysis and selecting 'New Analysis' will copy settings to a new analysis, which can be renamed (e.g., 'Truncated with Bins B', etc.) by double-clicking on the analysis name. Right-click on the analysis and select 'Item Properties' to open the 'Analysis Details' window and select the appropriate data filter on the 'Inputs' tab (Figure SOP 11.17.6).
- l. For each analysis, navigate to 'Plot: Detection Probability' in the 'Results' tab of the 'Analysis Details' window to evaluate how well shape criteria are met. Proceed upon selecting an appropriate binning strategy.

Selecting a Detection Function

After exploratory analyses to select a right-truncation distance and apply an appropriate binning strategy, the Project Leader will conduct analyses to select a model for estimation of a detection function. Program DISTANCE will use AIC to automatically select among alternative models the model that provides the most parsimonious fit to these data. However, AIC selection is blind to several critical criteria for robust estimation of a detection function, so the Project Leader will assess whether estimated detection functions achieve adequate goodness-of-fit and meet shape criteria. Problems may suggest revisions to models and/or binning strategies.

Detailed Steps

A. Project Leader Tasks

1. Execute AIC model selection
 - a. In the 'Analyses' tab of the 'Project Browser' select the 'Estimation' analyses set. Right-click on the '4model AIC selected' analysis and select 'Item Properties' to open the 'Analysis Details' window. On the 'Inputs' tab and select the data filter that was selected during the exploratory analyses (as shown in Figure SOP 11.17.6). If binning

- was unnecessary, this will be the 'Truncated' filter, otherwise it will be the data filter with the chosen binning strategy.
- b. Return to the 'Analyses' tab of the 'Project Browser,' execute the '4 model AIC selected' analysis, open the 'Analysis Details' window, and select the 'Results' tab (procedure shown in Figure SOP 11.17.1-2).
 - c. **AIC model selection:** AIC values are used to select the most parsimonious model structure. Lower AIC values indicate higher parsimony, and generally models within ~2 units of the top model also have substantial support. AIC selection is applied in 2 contexts during model selection. First, for each of the 4 alternative key function + series expansion combinations, AIC values are used to assess if the series expansion (which adds an additional parameter) increases parsimony relative to the key function alone. If the series expansion provides no improvement, it is dropped. Second, AIC is used to compare the 4 alternative models. In each analysis, AIC values for each model structure considered are reported in the 'Model Fitting' windows in the 'Results' tab of the 'Analysis Details' window. DISTANCE reports results only from the top model. AIC values can also be used to compare among analyses. In the 'Results' tab of the 'Project Browser,' DISTANCE reports the 'Delta AIC' (deviation of the top model in each analysis relative to the top overall model among analyses) for each analysis. *It is critical to realize that AIC values can only be compared when underlying data are identical.* Both the sample size as well as the binning strategy must be identical.
 - d. Use the drop down menu or the 'back' and 'next' buttons to navigate through the 'Model Fitting' windows in the 'Results' tab. The initial windows describe AIC selection relative to fitting the series expansion term for each of the 4 alternative models. The final window shows the AIC-selected top model among all 4 alternatives. This window also displays the '# of samples' (i.e., # of transects), the 'Width' (the right-truncation distance), and the '# of observations' (# of murrelet groups observed). Navigating to the next window ('Parameter Estimates') gives the same information along with estimates for parameters in the detection function (parameters shown in equation describing selected model) as well as probability of detection probability 'p' and the effective strip width 'ESW' (Figure SOP 11.18.1).
 - e. **Effective strip width:** This is the perpendicular distance within which as many groups as detected as are missed outside it. Equivalently, if all groups were detected within this distance, then the number of groups would be identical to the actual number of groups observed. The effective strip width provides an overall measure of detection probability relative to distance that facilitates comparisons among estimates with different detection functions and right-truncation distances.
 - f. **Detection probability:** The overall probability of detecting murrelet groups within the right-truncation distance.
2. Evaluate goodness-of-fit and detection function shape
 - a. The output for assessing goodness-of-fit will differ depending on whether binned or exact perpendicular distance data were used in analyses. For binned data, the window 'Chi-sq GOF Test' in 'Results' tab of the 'Analysis Details' window will display a χ^2

- goodness-of-fit test with bins matching those defined in the data filter. For analyses using exact distance data, the bins for the χ^2 test are defined by DISTANCE. For analyses using exact data, there will also be a q-q plot in the window 'Plot: qq-plot'.
- b. Goodness-of-fit and DISTANCE: Although several quantitative methods for selecting models and assessing goodness-of-fit exist in DISTANCE, they are of limited utility in guiding selection of a reliable detection function. While quantitative methods can be useful tools, application of sound principles and judgment are necessary to robust estimation of a detection function.
 - c. χ^2 goodness-of-fit test: This test provides a quantitative assessment of fit of the model to the data by comparing expected versus observed frequencies of observations in bins defined by perpendicular distance from the transect center line. *P*-values <0.05 indicate statistically significant lack-of-fit. However, the χ^2 test has significant limitations for assessing fit of estimated detection functions. First, the power of the test increases with sample size. Thus, as the number of observed groups increases the magnitude of deviation between the data and the detection function required to generate a statistically-significant difference decreases. Second, results are strongly dependent on the bins used to make comparisons, and the test is sensitive to poor binning strategies. Third, the test treats all bins equally and does not recognize the critical importance of bins at small distances. Fourth, the test does not consider shape criteria required for reliable estimation of detection functions. In sum, *P*-values should not be used as a comprehensive assessment of adequacy of estimated detection functions but can indicate potential goodness-of-fit problems. For individual bins, high χ^2 -values can be useful in highlighting at what distances goodness-of-fit problems are occurring.
 - d. q-q plots: Quantile-quantile plots provide a graphical measure of assessing fit of the model to the data are available for analyses using exact distance data. These plots compare the expected cumulative distribution function (blue line) from the estimated detection function to the actual distribution of the data (red dots). Data are sorted in increasing order, and the *x*-axis increases from 0 distance (left intercept) to the right-truncation distance (right intercept). Most points falling near the line indicates good fit, but systematic departures indicate lack of fit at specific distances.
 - e. Assessment of the detection function should focus on whether adherence to shape criteria (defined at step A.3.a in the 'Exploratory Analyses' section above) and goodness-of-fit are adequate.
 - f. Navigate to the 'Plot: Detection Probability' window the 'Results' tab to view the estimated detection function (red) and the histogram with frequencies of observed groups (blue) in defined bins (Figure SOP 11.18.2). This plot allows visual assessment of the shape of the detection function and the location and magnitude of deviations between predictions from the detection function and the histogram data.
 - g. Navigate to the 'Chi-sq GOF Test' window the 'Results' tab to view results from the χ^2 goodness-of-fit test (Figure SOP 11.18.3). The test will use the user-defined distance bins if present; otherwise, DISTANCE will conduct 2 tests (displayed in separate windows) using auto-generated bins. The sum of the χ^2 values across

distance bins ('cell' in the χ^2 table) gives the total χ^2 value, which is used to generate an overall P -value for the null hypothesis that the predicted and actual frequencies of observations are not different. See caveats on χ^2 testing above. The χ^2 values for each bin are useful for assessing goodness-of-fit at specific distance bins as well as comparing the magnitude of deviations among bins.

- h. **Goodness-of-fit and detection distances:** Distance sampling requires that all detection probabilities are scaled relative to that at the x -intercept, and it is usually assumed that detection is 100% at distances near 0. Therefore, it is critical that detection is accurately modeled near the x -intercept, and consequences of poor goodness-of-fit at small distances are more severe than at other distances. However, data at all distances are treated equally by current model-fitting and assessment techniques. Ideally, the detection function near the x -intercept should have a strong "shoulder" and close correspondence between predicted and actual observations. When data are binned, these guidelines should hold for the 2 bins at smallest distances. If goodness-of-fit is poor near the x -intercept, a detection function that is relatively too high or low can over- or under-estimate detection probability across all distances. A particularly troublesome case arises when detections are much more frequent in the 1st (smallest distance) relative to 2nd bin, as different models can have similar goodness-of-fit yet produce very different estimates (see Figure 2.5 and associated text in Buckland et al. 2001). If alternative binning strategies cannot produce a broader "shoulder" in the data distribution, then models with steep slopes at the x -intercept (i.e., that "climb the y -axis") should generally be avoided.
- i. If the AIC-selected detection function meets shape criteria and achieves adequate goodness-of-fit, then proceed to heading 3 below. Otherwise, the iterative process of selecting distance bins and fitting detection function models should continue until results are suitable.
- j. Consider altering binning strategies to produce histograms of frequencies of observations more conducive to achieving suitable detection functions. If frequencies of detections at large distances are hindering model fitting, it may also be worthwhile to adjust the right-truncation distance to improve distribution of the data.
- k. Problems in the AIC-selected detection function may highlight inadequacies in the selected binning strategy. The functional form of detection models may not be flexible enough to achieve adequate goodness-of-fit, especially if large changes in detection frequencies occur between adjacent bins. If so, changes to the binning strategy (A.3 in 'Exploratory Analyses' section above) may mitigate problems, although binning cannot fully resolve severe problems in data distribution.
- l. If binning has been optimized for these data, consider alternatives to the AIC-selected detection function model, either with different key function + series expansion combinations or for a key function without a series expansion term. To execute analyses consisting of individual detection function models, navigate to the 'Estimation' analysis set in the 'Analyses' tab of the 'Project Browser' (Figure SOP 11.19). Select and execute desired analyses. Compare the 'Delta AIC' values in the right pane to assess support for each model. In the 'Results' tab of the 'Analysis

- Details' window for each analysis, navigate to the 'Plot: Detection Probability' and 'Chi-sq GOF test' windows to assess detection function shape and goodness-of-fit.
- m. Problems may also arise from the inadequacy of the functional form of the AIC-selected detection function. Because AIC-selection procedures do not consider shape criteria or the heightened importance of goodness-of-fit near distance 0, it may be the AIC-selected model is inferior to models with slightly higher AIC values (i.e., ΔAIC of <2). Thus, it may be worthwhile to assess performance of models with different key function + series expansion combinations. Inclusion of series expansion terms can sometimes lead to undesirable or implausible curvature in the detection function, so considering key functions with fewer or no series expansion adjustment terms may improve detection function shape.
 - n. AIC values can only be used to compare alternative models of detection function for the same data set (i.e., identical sample and identical binning strategy). Therefore, if alternative binning strategies are considered, alternative detection functions models from different data sets can be compared using the χ^2 goodness-of-fit test and assessment of detection function shape. If alternative binning strategies are considered, it may be useful to create a new analysis set to segregate results using different data sets.
 - o. The iterative process of truncating data, selecting a binning strategy, fitting alternative models should lead to a detection function meeting shape criteria and achieving adequate goodness-of-fit. AIC model selection and goodness-of-fit tests are useful tools in this process, but ultimately the Project Leader must employ judgment to select a final detection function that is statistically reasonable and biologically plausible.
3. Applying the selected model to the 'Top Model Export Stats' analysis
- a. The selected binning strategy and selected model for estimation of a detection function should be applied to the analysis 'Top Model Export Stats' in the 'Estimation' model set.
 - b. Select the 'Analyses' tab in the 'Project Browser' window, and right-click the 'Top Model Export Stats' analysis and open the 'Analysis Details' window (Figure SOP 11.20.1).
 - c. Select the 'Inputs' tab and then select the 'Data filter' containing the binning strategy selected for estimation of the detection function.
 - d. Confirm that the 'Top model export stats' is selected in the 'Model definition' (Figure SOP 11.20.2).
 - e. Open the 'Model properties' window and select the 'Detection function' tab and the 'Models' lower-level tab (Figure SOP 11.20.2-3).
 - f. Reduce the number of models to one and select the key function and series expansion used to estimate the detection function (Figure SOP 11.20.3).
 - g. In the 'Adjustment terms' lower-level tab (Figure SOP 11.20.4), manually input the number of adjustment parameters (i.e., terms in the series expansion). If a series expansion was included, there will normally be 1 parameter. If no series expansion was included in the detection function model, set this number to "0".

- h. Open the 'Model definition properties' window and select the 'Misc.' tab (Figure SOP 11.20.5).
- i. Enter a path for the output text file
“\\inpglbafs03\data\SEAN_data\Work_zone\KM\KM_Jyyyy\DFstats_yyyy.txt”, where yyyy is the survey year, and confirm the change (Figure SOP 11.20.6).
- j. Running this analysis will export the results file (section 7) and also will generate estimates of group size (section 6). Be sure to verify that results match those for the selected detection function model.

Estimating Group Size Using DISTANCE

Because encounter rates are calculated for groups of individuals, estimates of average group size are required to estimate density and abundance. However, if large groups are more likely to be detected at large distances, then the average calculated from observed groups will be positively biased. Regression techniques can test for presence of such size bias and, if present, correct for it by predicting average group size for detection probability = 1. Because of the strong shoulder observed in the detection function for these surveys (Hoekman et al. 2011a, b), it was unlikely that a linear regression of group size on perpendicular distance to the transect center line would provide adequate fit to our data. Therefore, we took the approach of regressing $\ln(\text{group size})$ on the estimated detection probability for each group from the selected detection function (Buckland et al. 2001). Analyses should be conducted separately for each species class (KIMU, MAMU, and unidentified *Brachyramphus* murrelets). Average group size should be preferred, except when strong evidence supports use of expected group size from regression analyses. All survey transects should be used for estimation of group size for analyses of population trend. However, one transect (016) selected using non-probabilistic methods should be excluded from estimation of group size for analyses of population status (see Appendix B, section B.7.3).

Detailed Steps

A. Project Leader Tasks

1. Generating and viewing estimates of group size for analyses of population trend
 - a. In DISTANCE, open the project file for the current survey year, navigate to the 'Project Browser', and select the 'Estimation' model set. Select the 'Top model export stats' analysis in the "Estimation" model set and run it by right-clicking and selecting 'Run analysis' option.
 - b. Right-click this analysis again, and then select the "Analysis details" option and select the 'Results' tab.
 - c. Use the drop-down menu or the 'Back/Next' keys to navigate to the pages with the 'Cluster size-Estimates' for each species class (K/M/U). On these pages, '# observations' gives the sample size, ' $\Pr(T < t) =$ ' gives the *P*-value of the regression of $\ln(\text{group size})$ on predicted detection probability, estimates for 'Expected cluster size' are for estimates of group size when detection probability = 1 from the regression analyses, and estimates for 'Mean cluster size' are simply the average group size.

- d. Pages of the cluster size results with the 'Regression plot' title give a text based graphical presentation of the regressions. The estimated regression line is represented by asterisks "*", while open circles "o" represent one or more data points.
 - e. The 'Estimation summary – expected cluster size' window contains a summary of estimates for each species class along with degrees of freedom and 95% confidence intervals. On this page, estimates from the regression analyses are labeled "*r*" (correlation coefficient), "*r-p*" (*P*-value), and "E(S)" (expected group size).
2. Interpreting estimates of group size
- a. For each species class, the Project Leader must select the best estimate of group size for estimation of density and abundance.
 - b. Typically, average group size should be preferred. However, predicted group size for detection probability = 1 from regression analyses may be preferred when strong evidence supports size bias in detection of groups. Strong evidence should include "statistically significant" results from regression analyses (i.e., $P < 0.05$), a negative slope parameter estimate, and satisfactory adherence to assumptions of regression analyses.
 - c. For regressions with negative slope coefficients and $P < 0.05$, examine regression plots to assess whether results are robust to data outliers. In particular, one or a few large groups with low predicted detection probability may create "high leverage points" that unduly inflate to the steepness of a negative slope coefficient. If the "statistical significance" of a regression depends on these high leverage points, averages may provide more reliable estimates of group size.
 - d. If the influence of data outliers on results is unclear, users confident in use of DISTANCE may find it useful to compare results with and without outliers. If regression estimates only receive strong support with outliers, then average estimated group size likely will be more reliable. To filter outliers for a given species class:
 - i. In the 'Cluster size – Regression plot' page in the 'Results' tab of the analysis under consideration, note a cut-point on the on the y-axis ("log of cluster size") that separates outliers from other data, and transform this value to natural units by taking the inverse log.
 - ii. Select 'View|Analysis Components', click the 'Data Filters' button, select the data filter used for the analysis under consideration, right-click and select 'New Item' to create a new data filter. If the settings of the original filter have been successfully copied, the new filter will have the name of the original with a "1" appended. The new filter can be renamed by double-clicking on the name.
 - iii. Left-click to highlight the new filter, right-click and select 'Item properties' to open the 'Data filter properties' box. On the 'Intervals', 'Truncation', and 'Units' tabs, confirm that the selections are identical to the data filter used by the original analysis under consideration.
 - iv. On the 'Data selection' tab (shown in Figure SOP 11.6.4), left-click the "+" button to the right of the 'Data selection' box to add a row in the box. In the drop-down menu under 'Layer type', select "Observation". Left-click the text

box immediately to the right and enter "[Cluster size] < X" (without quotations), where X = the inverse log of cut-point value chosen above. Left-click 'OK' to save changes.

- v. Select 'View|Project Browser' and navigate to the 'Estimation' analysis set. Select to highlight the analysis under consideration, and right-click and select 'New analysis'. If analysis settings have been successfully copied, the new analysis will have the name of the original with "1" appended. The new filter can be renamed by double-clicking on the name.
 - vi. Select and right-click this new analysis and choose 'Analysis details' to open the 'Analysis details' window. On the 'Inputs' tab, confirm that the 'Model definition' is the one for the model under consideration, and then double left click on the newly-created data filter to select it. Click the 'Run' button to execute the new analysis.
 - vii. Select the 'Results' tab and navigate to the group size regression results for the species class in question. Confirm that the outliers have been filtered from analyses. Compare the slope coefficients and *P*-values between this analysis and the original analysis.
 - viii. Comparison of analyses with and without outliers is useful to determine effects of outliers on results, but should not be used for estimation of density and abundance. If support for regression analyses depends on few outliers, estimates of average group size may be preferred over estimates from regression analyses.
 - e. Output exported from DISTANCE will contain estimates and associated parameters for both average group size and predicted group size from regression analyses. The Project Leader must use statistical criteria above and judgment to select the most appropriate estimates of group size for each species class.
3. Specifying selected estimates of group size
- a. The selected estimates of group size for each species class must be manually specified in the "DFstats_yyyy.txt" file (created at A.3.i in the 'Selecting a Detection Function' section above), and the edited file is saved in the comma delimited file format (.csv). A text editor or spreadsheet software can be used for editing; here we provide directions using Microsoft Excel 2010.
 - b. In Excel, select the 'File' tab, and click 'Open'. In the drop down menu to the right of the 'File name' box, select 'All files'. Navigate to the folder containing "DFstats_yyyy.txt", select it, and click 'Open'.
 - c. In the 'Text Import Wizard – Step 1', select 'Delimited' original data type and click 'Next'.
 - d. In the 'Text Import Wizard – Step 2', select the 'Space' delimited file type, select 'Treat consecutive delimiters as one', and click 'Next'.
 - e. In the 'Text Import Wizard – Step 3', select the column data format 'General' and click 'Finish'. The text file should be displayed in a spreadsheet. Data in each row are coded as specified in Table SOP 11.3, with columns numbered from left to right, starting with the first column containing values. In Excel, sequential columns will be

- labeled “A, B, C . . .” rather than “1, 2, 3 . . .”. Excel may create an additional column at the left containing no values; hence column 1 in Table SOP 11.3 may correspond to column “B” in Excel.
- f. The 1st column from the left (labeled ‘B’ in Excel) should be the first column with values, which specify the species class for group size estimates on that row: 1 = Kittlitz’s murrelet, 2 = marbled murrelet, and 3 = unidentified murrelet.
 - g. The 4th and 5th columns (‘E’ and ‘F’ in Excel) specify rows with group size estimates: values of 3 and 1 correspond to estimates of average group size, 3 and 4 to regression estimates.
 - h. For each species class, place a “Y” in the 2nd column (‘C’ in Excel) on the row with the selected estimate of group size and an “N” in the row of the other estimate of group size. Other rows of this column should contain the value ‘0’; leave these unchanged.
 - i. Save the edited file in the comma delimited file format (.csv). In Excel, select the ‘File’ tab, click on ‘Save As’, and in the drop down menu next to “Save as type:” select ‘CSV (comma delimited)’. Enter a path for the output file [“\\inpglbafs03\data\SEAN_data\Work_zone\KM\KM_Jyyyy\DFstats_yyyy.csv”](\\inpglbafs03\data\SEAN_data\Work_zone\KM\KM_Jyyyy\DFstats_yyyy.csv), where yyyy is the survey year, and click ‘Save’.
4. Generating and viewing estimates of group size for analyses of population status
- a. In the ‘Analysis Components’ window, open the ‘Data filters’ window, select and right-click on the ‘Truncated Bins A Status’ filter to open the ‘Data filter properties’ window (Figure SOP 11.17.3). Enter the binning strategy used to estimate the detection function (Figure SOP 11.17.4). This will be the binning strategy from the data filter selected at step A.3.c in the ‘Selecting a Detection Function’ section above.
 - b. As in Figure SOP 11.20.1, select the ‘Analyses’ tab in the ‘Project Browser’ window, and select and right-click the ‘Top Model Export Stats Status’ analysis and open the ‘Analysis Details’ window.
 - c. On the “Inputs’ tab, confirm that the ‘Truncated Bins A Status’ model filter and the ‘Top model export stats status’ model definition are selected (Figure SOP 11.20.2).
 - d. Open the ‘Model properties’ window as in Figure SOP 11.20.2, and apply the model selected for estimation of the detection function (Figure SOP 11.20.3-4) as detailed in steps under the A.3 heading in the ‘Selecting a Detection Function’ section above.
 - e. Open the ‘Model definition properties’ window and select the ‘Misc.’ tab (Figure SOP 11.20.5).
 - f. Enter a path for the output text file \\inpglbafs03\data\SEAN_data\Work_zone\KM\KM_Jyyyy\DFstats_status_yyyy.txt, where yyyy is the survey year, and confirm the change (Figure SOP 11.20.6).
 - g. In the ‘Project Browser,’ select the ‘Top model export stats status’ analysis in the “Estimation’ model set and run it by right-clicking and selecting ‘Run analysis’ option. This generates estimates of group size and the associated output file for analyses of population status.
 - h. Using the ‘Top Model Export Stats Status’ analysis, repeat steps in A.1 above to assess whether estimates of average group size or estimates of expected group size

from regression analyses should be used in analyses of population status. Typically, group size results will be very similar to those for analyses of population trend.

- i. Repeat steps in section A.3, except substituting "DFstats_status_yyyy.txt" at step b and "DFstats_status_yyyy.csv" at step i.

Assembling the KM_J Deliverable

After selecting a detection function and estimates of group size for use in analyses of population status and trend for the current year's survey data, the Project Leader will 1) create a figure of the estimated detection function and 2) assemble this figure and the.csv files containing output from Program DISTANCE in an archive file. The Data Manager will import these into deliverable KM_J: Detection function.

Detailed Steps

A. Project Leader Tasks

1. Export the detection function from Program DISTANCE and create a figure in the .png image file format.
 - a. In DISTANCE, open the project file for the current survey year, navigate to the 'Project Browser', and select the 'Estimation' model set. After executing the 'Top model export stats' analysis, select and right-click on this analysis and open the results window by choosing 'Analysis Details'.
 - b. Select the 'Results' tab, navigate to the 'Plot: Detection Probability' window using the drop down menu, and then select 'Analysis – Results|Copy Plot to Clipboard' from the menu (Figure SOP 11.21).
 - c. Using a text editor such as Notepad, open a text file and paste the clipboard material into this file.
 - d. Save the file as unformatted text using the path "[\\inpglbafs03\data\SEAN_data\Work_zone\KM\KM_J\yyyy\DFplot_yyyy.txt](#)", where yyyy is the survey year.
 - e. Open Program TINN-R and use the 'File|Open' menu command to open the file 'DFplot.r' in the editor (Figure SOP 11.22).
 - f. Open an R GUI window using the 'R|Start/close and connections|Rgui (start)' menu command (Figure SOP 11.22).
 - g. In the user input section at the top of the 'DFplot.r' file, edit 'path' and 'outpath' input lines to specify the full path to the input file 'DFpoly_yyyy.txt' and the full path for the output file 'DFplot_yyyy.png', where yyyy is the survey year. Input lines also allow specification of text on the x- and y-axes.
 - h. Other features of the plot (e.g., font size, line width, image type for output, etc.) can be modified below the user-input area using the R computing language.
 - i. After making adjustments, executing the R code using the 'R|Send|File (echo=TRUE)' menu command or corresponding menu button will create an image file containing a plot of the detection function along with a histogram showing the frequency of observations of murrelet groups in each distance category (Figure SOP 11.22). The plot will also be displayed in the R graphical output window.
2. Use WinZip or similar tool to assemble the KM_J deliverable.

- a. Include the two .csv files containing output from Program DISTANCE created above (“DFstats_YYYY.csv” and “DFstats_status_YYYY.csv”) and one graphic of the detection function created above.
- b. Name the final product
\\inpglbafs03\data\SEAN_data\Work_zone\KM\KM_J\YYYY\KM_J_YYYY.zip

Formal Validation and Certification

The SEAN data management plan requires all monitoring deliverables be formally validated against rules defined in the protocol. When they have met all mandatory criteria, the Project Leader may declare them certified in writing. Once certified, the Data Manager must install them in repositories and attach them to electronic dissemination services.

Detailed Steps

A. Project Leader Tasks

1. Request validation by sending a notification email to the Data Manager, specifying in the message body that deliverable KM_J, for year YYYY is ready; the Data Manager will know where to find the file named “KM_J_YYYY.ZIP”.

B. Data Manager Tasks

1. On receipt of the submission, assign the next formal Submission Number to this file, as found in the master Submission_Log table.
 - a. Use the “Update Submission Log” web tool at http://165.83.57.239/0_submission_update.aspx.
 - b. Complete Submission_Log details up through the Submission_Date column.
2. Copy the file into the staging area for validation at a subdirectory named with the submission number in \\inpglbafs03\data\SEAN_Data\Staging\KM\KM_J.
3. Validate the submission according to current criteria.
 - a. Invoke validation of the ZIP file according to current criteria by using the web program at http://165.83.57.239/KM_DM_validate_KMJ.aspx.
 - b. Validation summary results automatically are recorded in the Submission_Log.
4. If submission fails any mandatory criteria, reply with a “failure email” that includes:
 - a. The submission number assigned
 - b. The deliverable ID
 - c. The protocol ID
 - d. Documentation listing all the criteria failed
5. If submission passes mandatory criteria, reply with a “success email” that includes:
 - a. The submission number assigned
 - b. The deliverable ID
 - c. The protocol ID
 - d. Documentation listing any specific optional criteria failed
 - e. Request to certify deliverable as complete

C. Project Leader Tasks

1. On receipt of a failure email:

- a. Review the validation report and remedy the mandatory errors by revising the analysis.
- b. Initiate a new submission with the Data Manager.
2. On receipt of a success email, review any failed optional criteria:
 - a. If the criteria review indicates the validated data are acceptable:
 - i. Reply with a "certification email" stating the deliverable is certified and may be disseminated.
 - b. If the validated data are unacceptable:
 - i. Reply with a "withdrawal email", stating the deliverable is withdrawn.
 - ii. Take remedial action to obtain and resubmit a corrected deliverable, if possible.

D. Data Manager Tasks

1. On receipt of a withdrawal email:
 - a. Mark the withdrawal in the Submission_Log's Status column using the web tool.
 - b. Terminate the process.
2. On receipt of a certification email:
 - a. Verify no sensitive information is in the deliverable. Products containing sensitive information cannot be disseminated. If sensitive:
 - i. Mark the sensitive designation in the log's submission status column using the web tool.
 - ii. Notify the submitter of the situation.
 - iii. Complete the deliverable tracking spreadsheet cells referring to dissemination with the word SENSITIVE.
 - iv. Do not attempt to install the sensitive item in the auxiliary repository.
 - b. Copy the submitted file to the integration environment at AUXREP\KM\KM_J\
 - c. Create an appropriate web link accessible from the KM main page.
 - d. Test accessibility until successful, then propagate from integration to production environment.
 - e. Verify deliverable is accessible from production web site.
 - f. Mark the certification in the Status column in Submission_Log using the web tool
 - g. Update the deliverable tracking spreadsheet milestones with the date of completion for KM_J.
 - h. Update the scope of the formal metadata so it includes this new date range.
 - i. Update the database to reflect the new or revised status and trends values by invoking the web program at http://165.83.57.239/KM_DM_update_KME_with_KMJ.aspx which accomplishes:
 - i. Importing the estimated detection function and estimates of group size for population trend analyses.
 1. The DFstats file exported from DISTANCE to "[\\inpglbafs03\data/SEAN_data/Work_zone/KM/KM_J/yyyy/DFstats_YYYY.txt](http://inpglbafs03\data/SEAN_data/Work_zone/KM/KM_J/yyyy/DFstats_YYYY.txt)", where yyyy is the survey year, is a space-delimited text file with 10 columns and a variable number of rows.

2. The content in each row is coded by values in rows 1,4, and 5 (Table SOP 11.3).
 3. The right-truncation distance should be parsed from the text file.
 4. The following estimated parameters along with estimated coefficients of variation (CV) and degrees of freedom (df) should be parsed from the text file:
 - i. Detection probability within right-truncation distance
 - ii. Effective strip width
 - iii. Parameter estimates for detection function
 5. For each of the above estimated parameters, the standard error should be calculated as the product of the parameter estimate and its CV.
 6. The rows for the key function and series expansion provide integer values that correspond to the combination of key function + series expansion used in the estimated detection function (Table SOP 11.3). A series expansion is not always present.
 7. The number of estimated parameters m for the detection function varies and will be the sum of the # of key function parameters and the # of series expansion parameters. The coded values in column 5 for these estimates will range from 101 to $101 + (m - 1)$. The key function parameter estimates are provided before those for the series expansion.
 8. All estimated parameters from the detection function should be parsed from the text file. Parameter estimates for the key function should be labeled in sequence prefixed by an 'A'. Parameter estimates from the series expansion should be labeled in sequence prefixed by a 'B'.
 9. Estimates of average group size for each species class are for analyses of population trend.
- ii. Importing the estimates of group size for population status.
 1. Use the DFstats_status file, a space-delimited text file with 10 columns and a variable number of rows.
 2. The content is coded identically to the 'DFstats' text file (Table SOP 11.3).
 3. Only the estimates related to average group size for each species class should be parsed from this file and imported to the KM_E database.

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.
- Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2004. Advanced Distance Sampling: Estimating Abundance of Biological Populations. Oxford, New York, New York, USA.
- Burnham, K. P., and D. R. Anderson. 2002. Model Selection and Multi-model Inference, second edition. Springer, 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: 2009 annual report. Natural Resource Technical Report NPS/SEAN/NRTR—2011/440. 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_2009_Annual_report.pdf
- Hoekman, S. T., B. J. Moynahan, and M. S. Lindberg. 2011b. 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
- Thomas, L., S. T. Buckland, E. A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R. B. Bishop, T. A. Marques, and K. P. Burnham. 2010. Distance software: Design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology* 47:5–14.

SOP 11 Figures and Tables

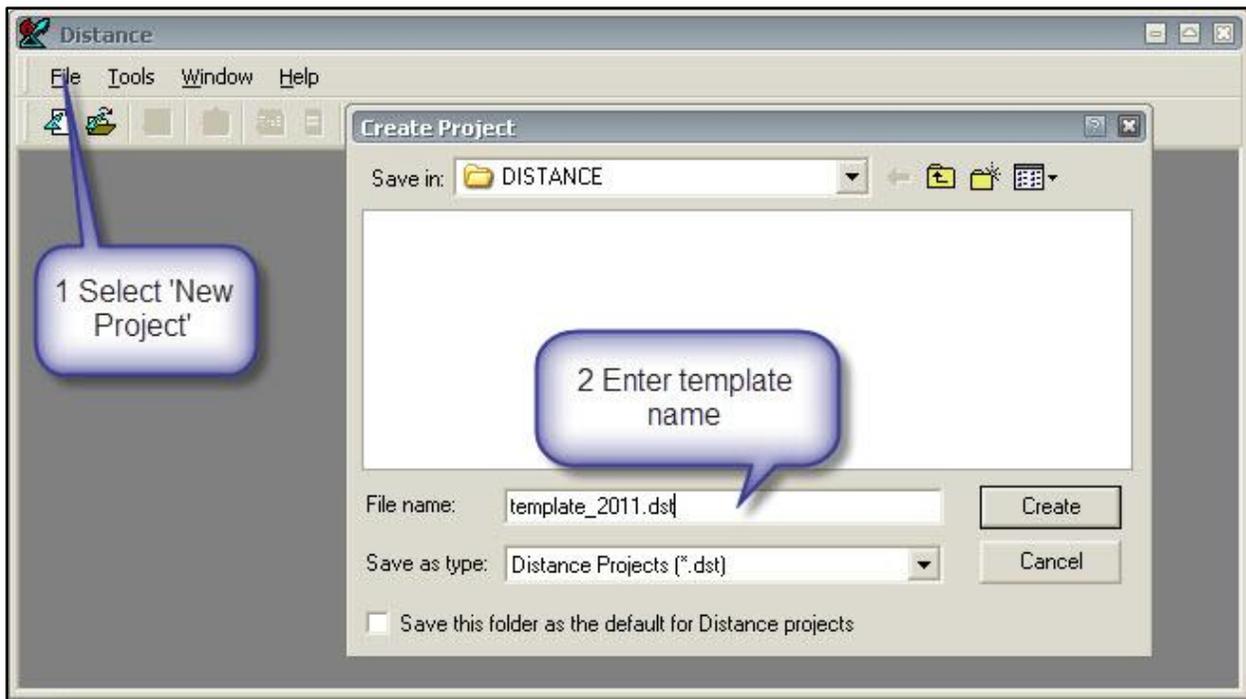


Figure SOP 11.1. Creation of a template project file in Program DISTANCE.



Figure SOP 11.2. Selection of appropriate settings using the 'New Project Setup Wizard' during creation of a DISTANCE project template file. Gold boxes indicate the sequence of steps; red arrows highlight user input.

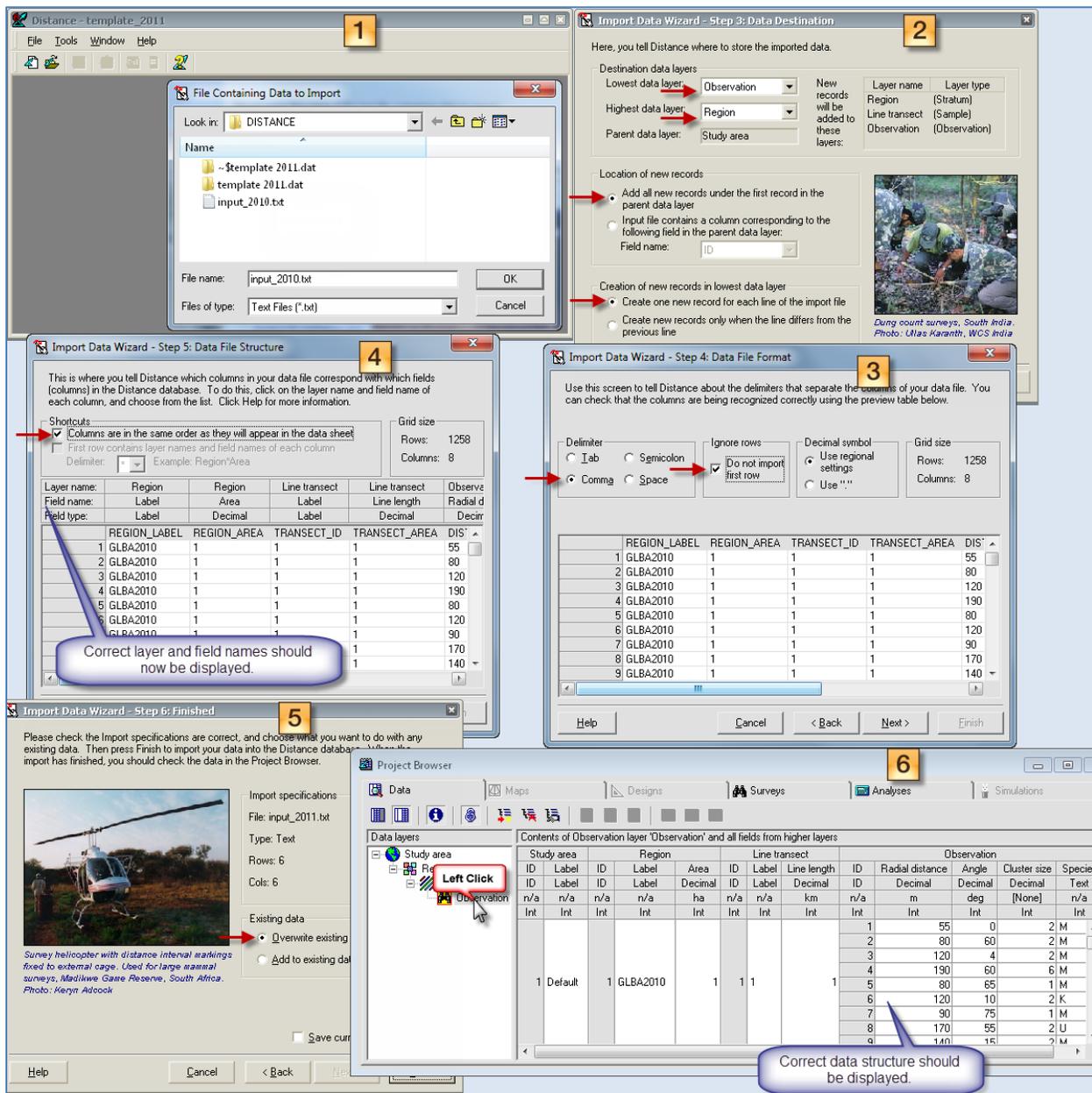


Figure SOP 11.3. The 'Import Data Wizard' of DISTANCE requires an appropriately formatted text file containing survey observation data. Successive steps of the Wizard allow specification of data structure. Upon completion of the Wizard, clicking on the 'Observation' data layer in the 'Data' tab of the 'Project Browser' window displays the imported data. Gold boxes indicate the sequence of steps; red arrows highlight user input.

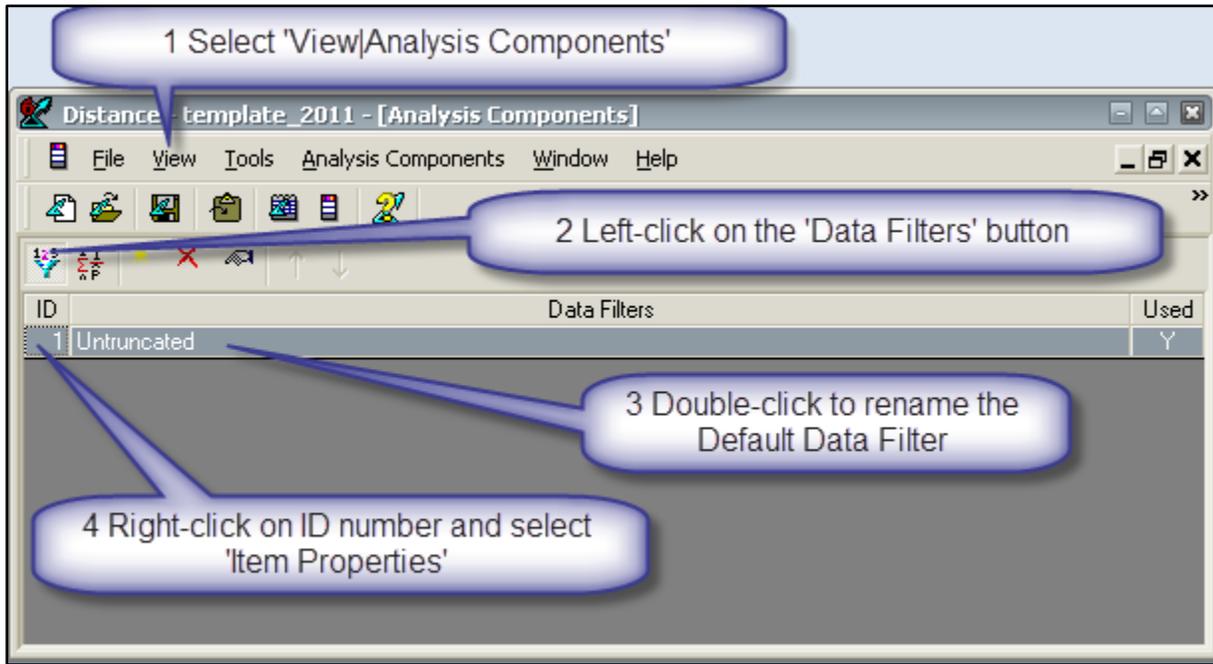


Figure SOP 11.4. Creation of a 'Data Filter' in the 'Analysis Components' window of DISTANCE. Selecting 'Item Properties' opens the 'Data Filter Properties' window shown in Figure SOP 11.5.

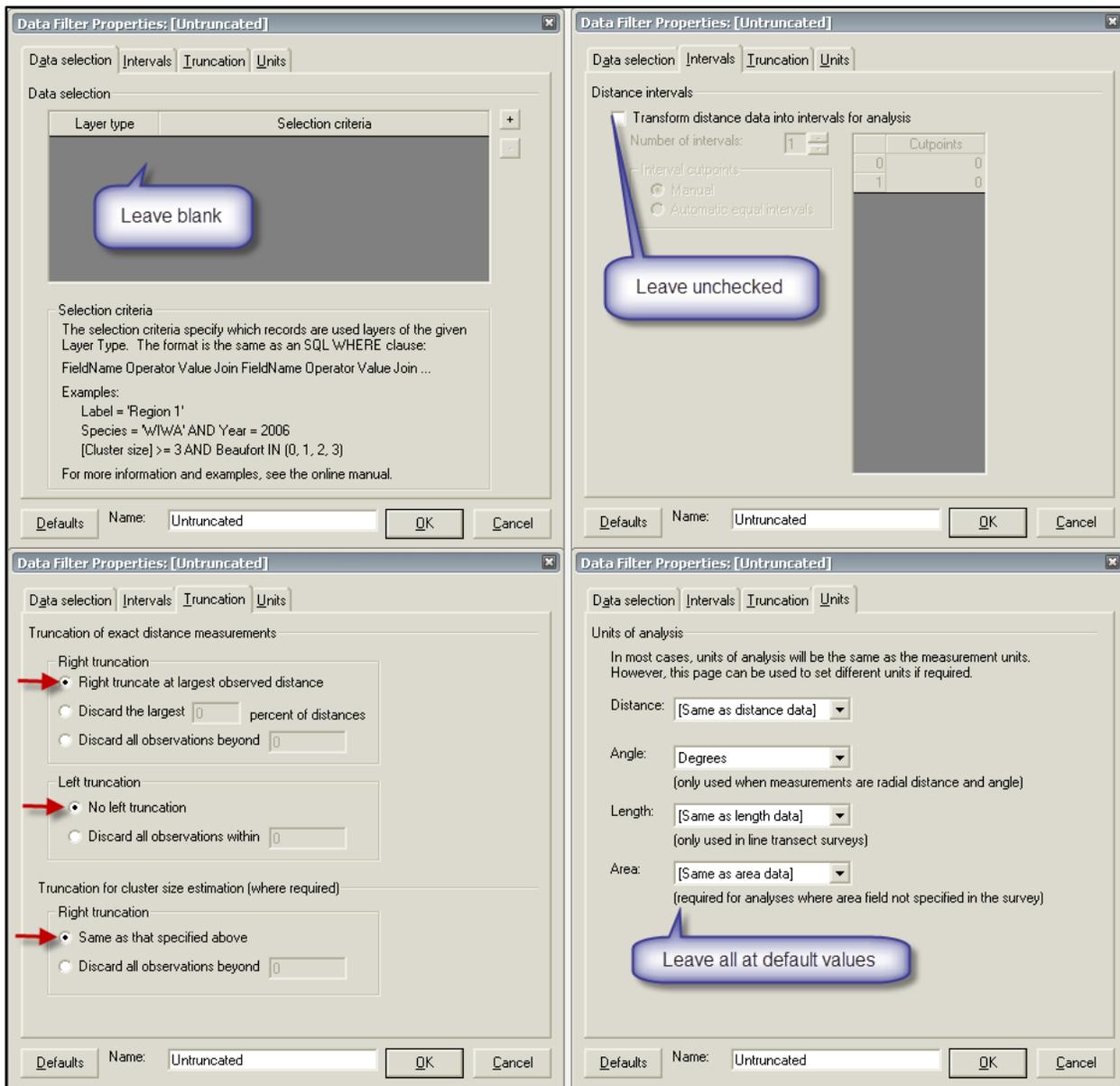


Figure SOP 11.5. The 4 tabs of the 'Data Filter Properties' window, showing appropriate settings for the "Untruncated" data filter. Red arrows highlight used input. Left-clicking 'OK' returns to the 'Analysis Components' window.

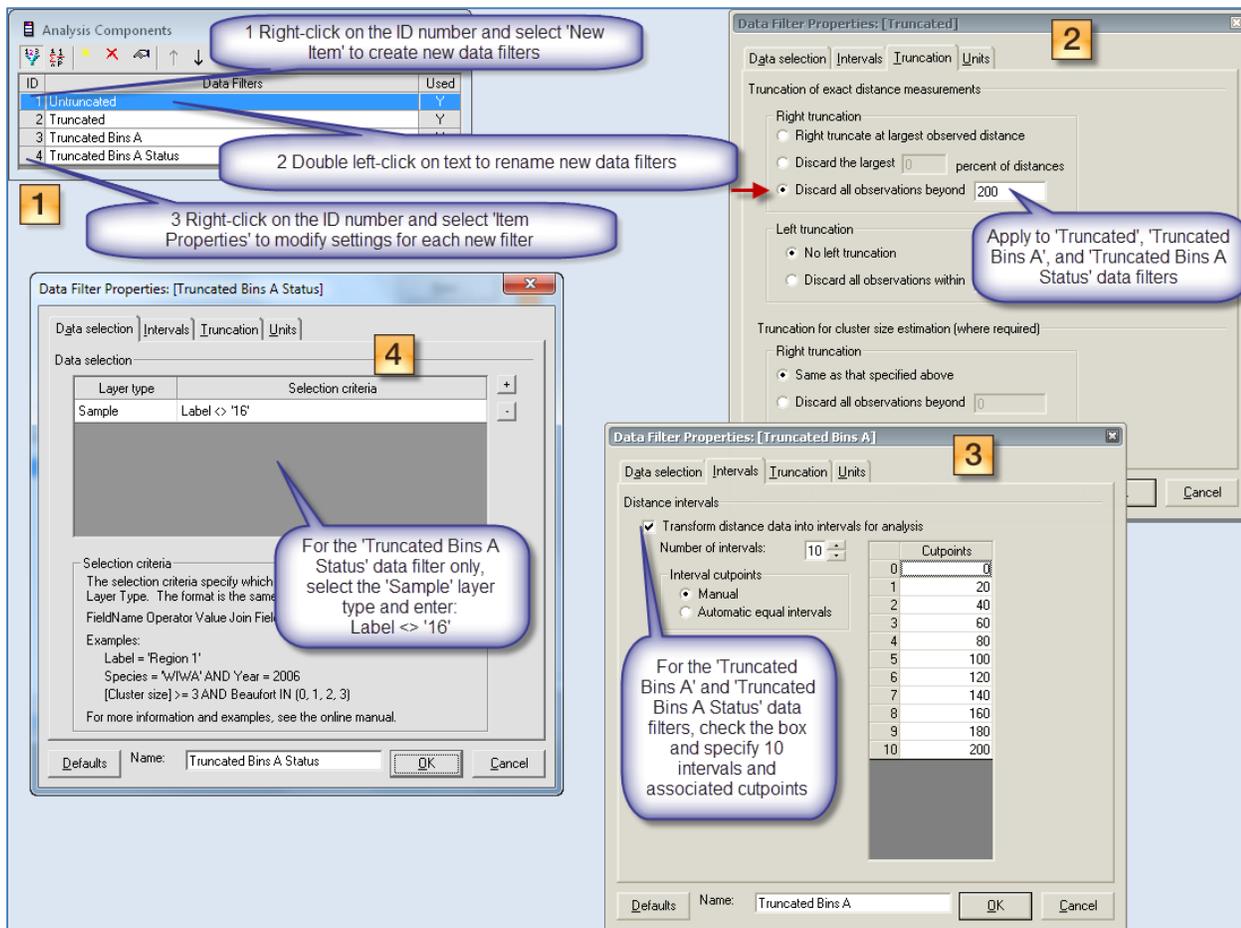


Figure SOP 11.6. Creation of additional data filters in the 'Analysis Components' window of DISTANCE. Step 2 shows settings changes applied to both the "Truncated" and "Truncated Bins A" data filters on the 'Truncation' tab of the 'Data Filters Properties' window. Step 3 shows settings changes applied only to the "Truncated Bins A" data filter in the 'Intervals' tab of the 'Data Filter Properties' window.

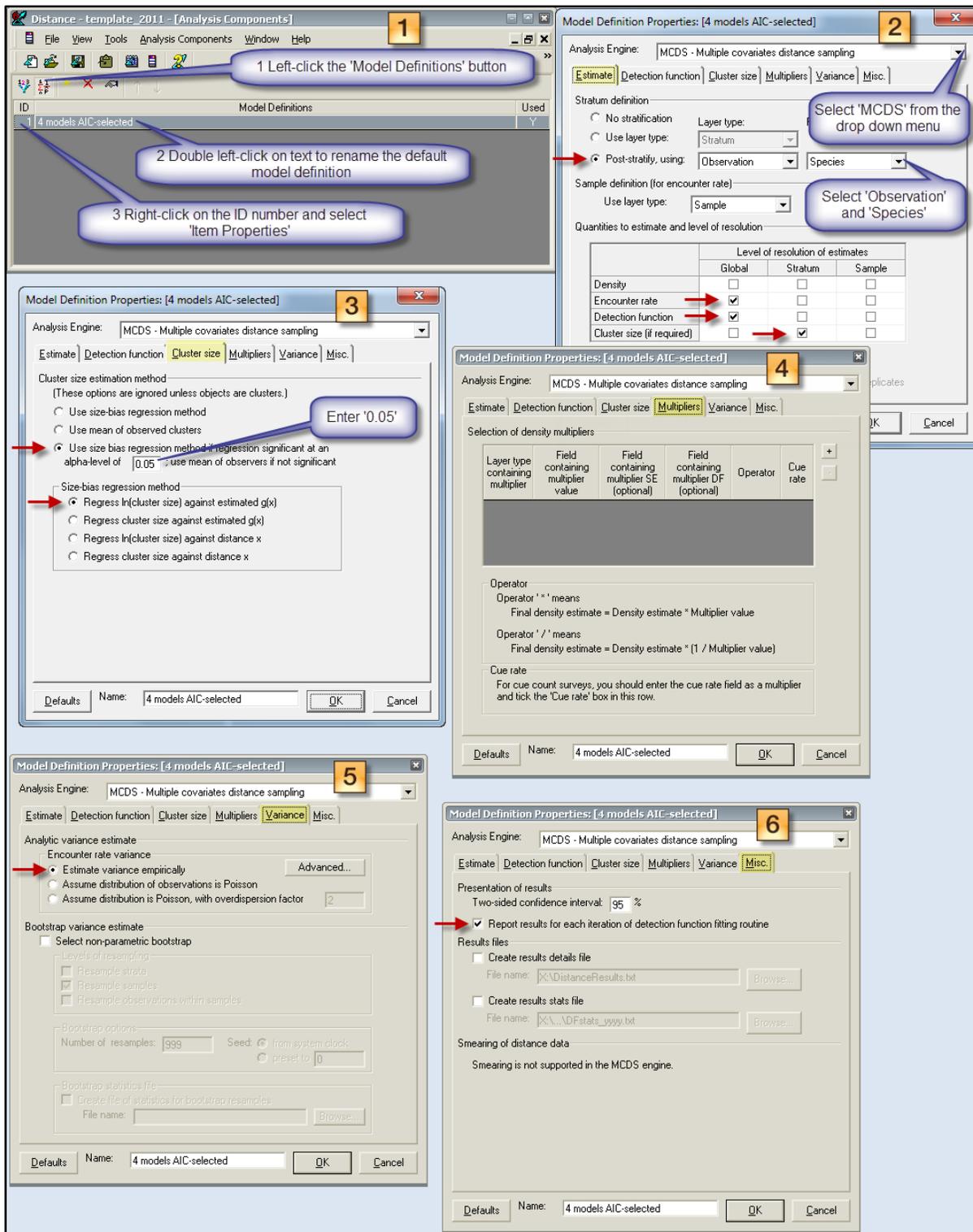


Figure SOP 11.7. Creating and defining the 'model definition' named "4 model AIC-selected". In step 1, the 'model definition' is named in the 'Analysis Components' window. Selecting 'Item Properties' opens the 'Model Definition Properties' window. Steps 2-6 show settings in all tabs except 'Detection function', which is shown in Figure 11.8. Red arrows highlight user input.

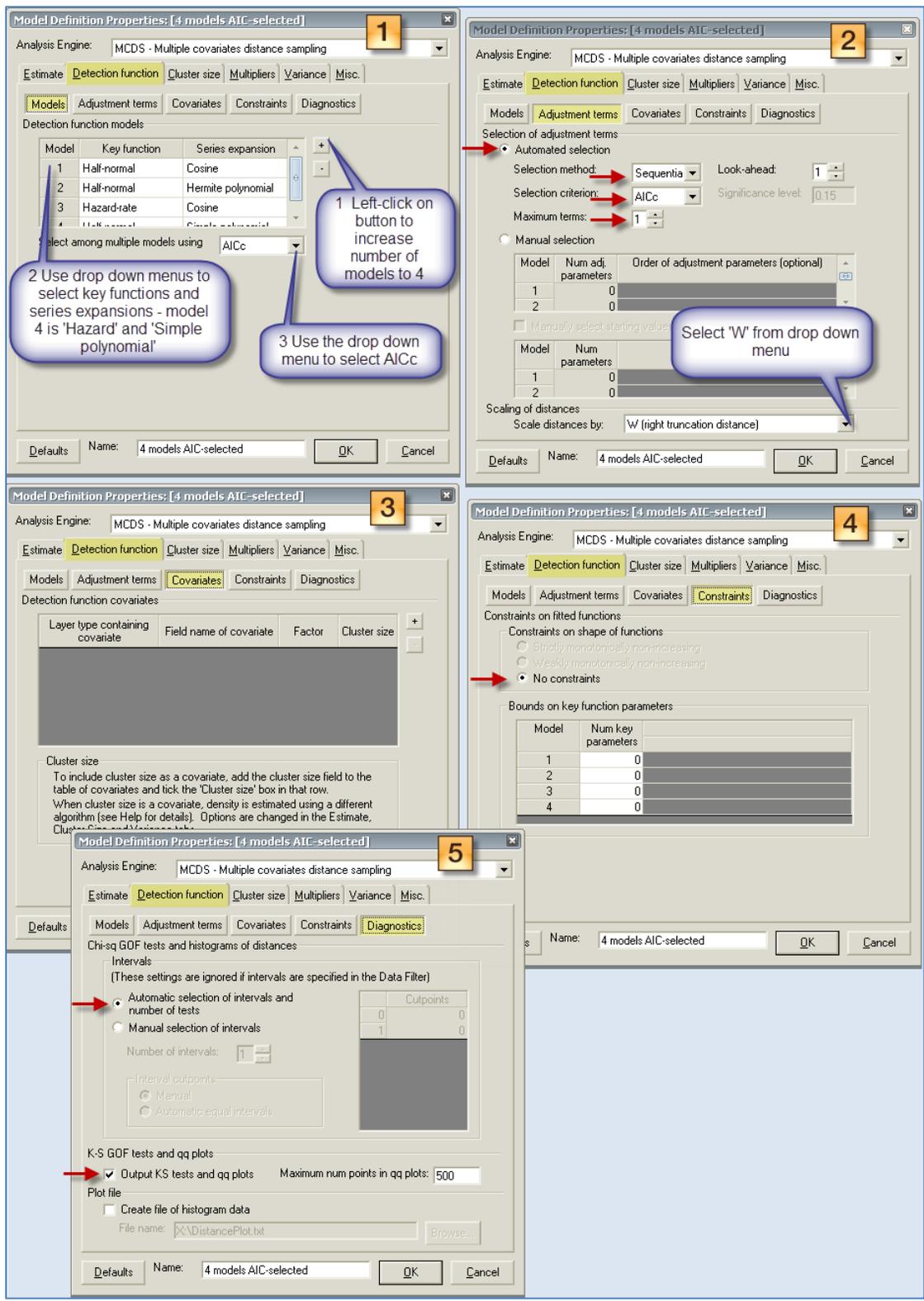


Figure SOP 11.8. Settings for the “4 models AIC-selected” model definition within the ‘Detection function’ tab of the “Model Definitions Properties’ window. This tab has 5 separate lower-level tabs, each shown in a separate window. Red arrows highlight user input.

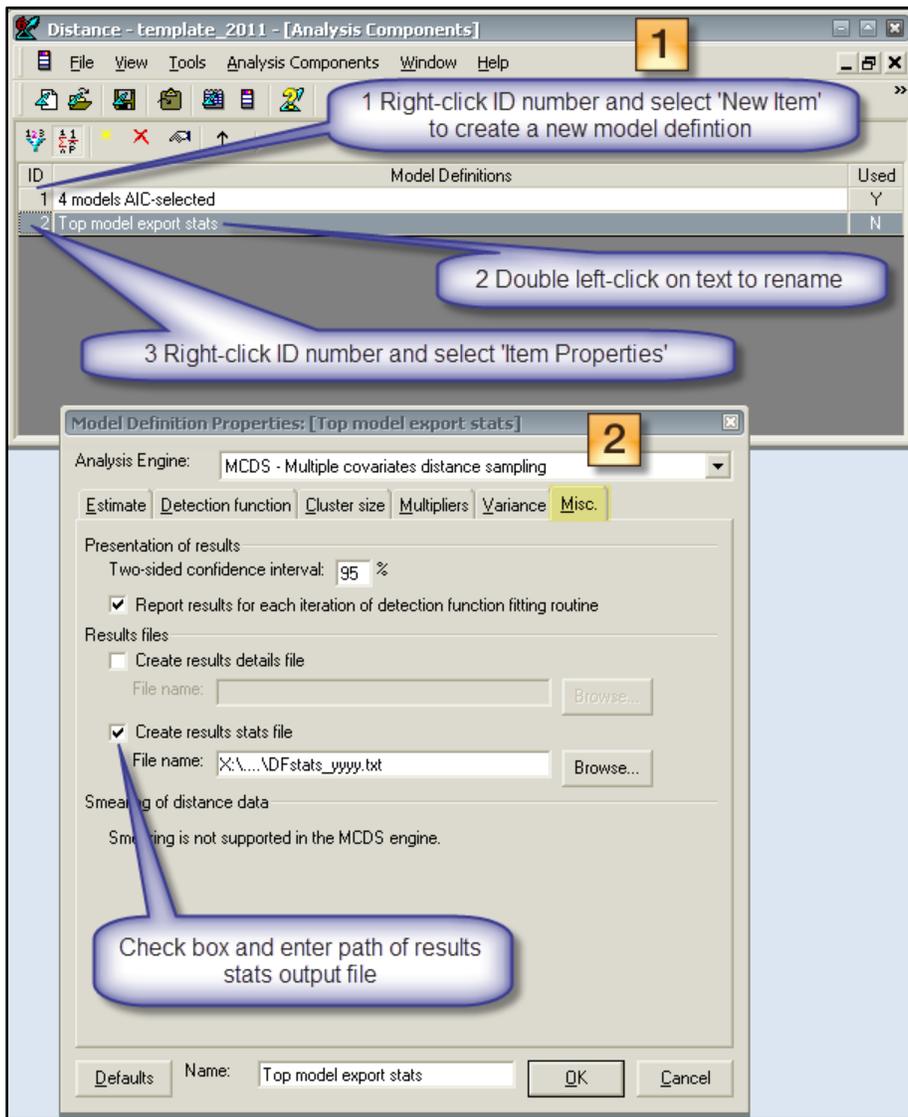


Figure SOP 11.9. Creating and naming the “Top model export stats” model definition in the ‘Analysis Components’ window. Settings for this model definition match those for the “4 models AIC-selected” model definition, except for the creation of a results stats output file. This file’s output path is specified in the ‘Misc.’ tab of the ‘Model Definition Properties’ window.

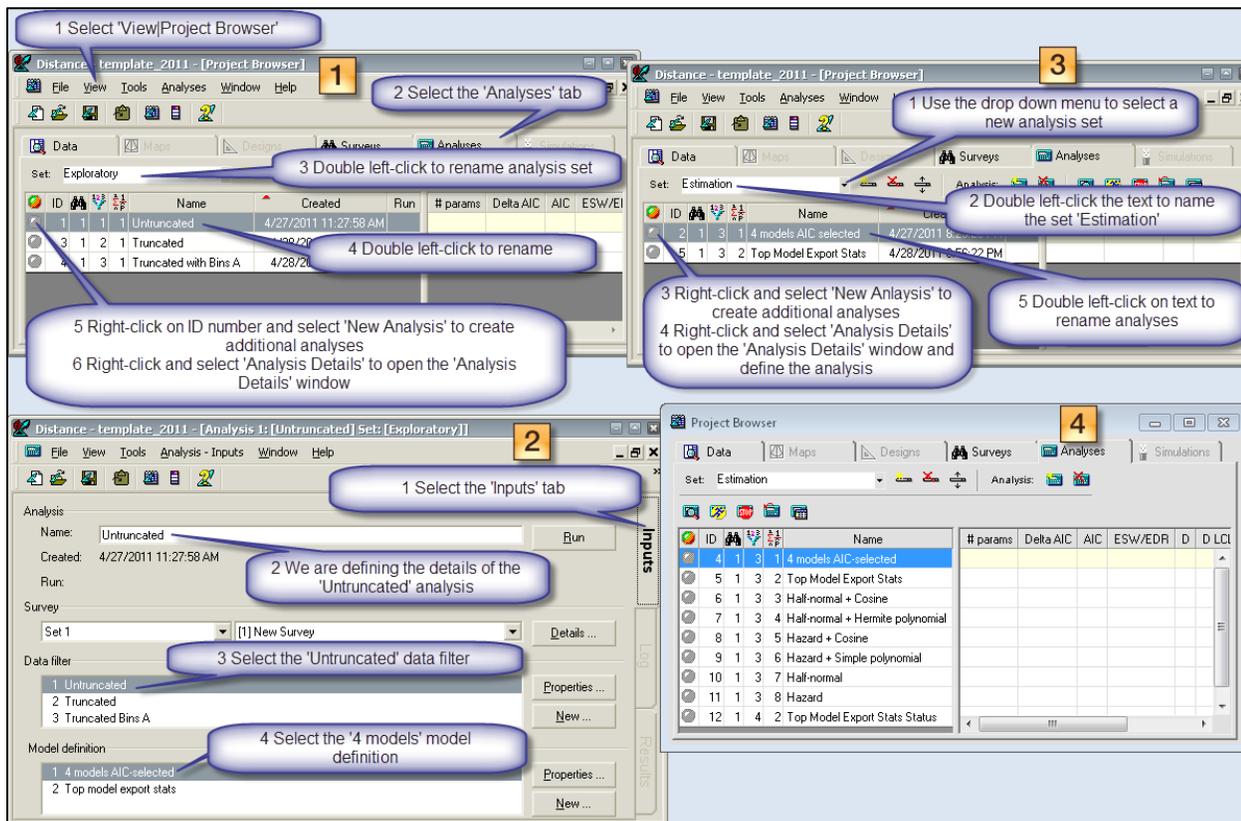


Figure SOP 11.10. Creating and specifying pre-defined analysis sets and analyses in the 'Analysis Components' window. The analysis sets and the names, data filters, and model definitions of analyses are listed in Table SOP 11.2.

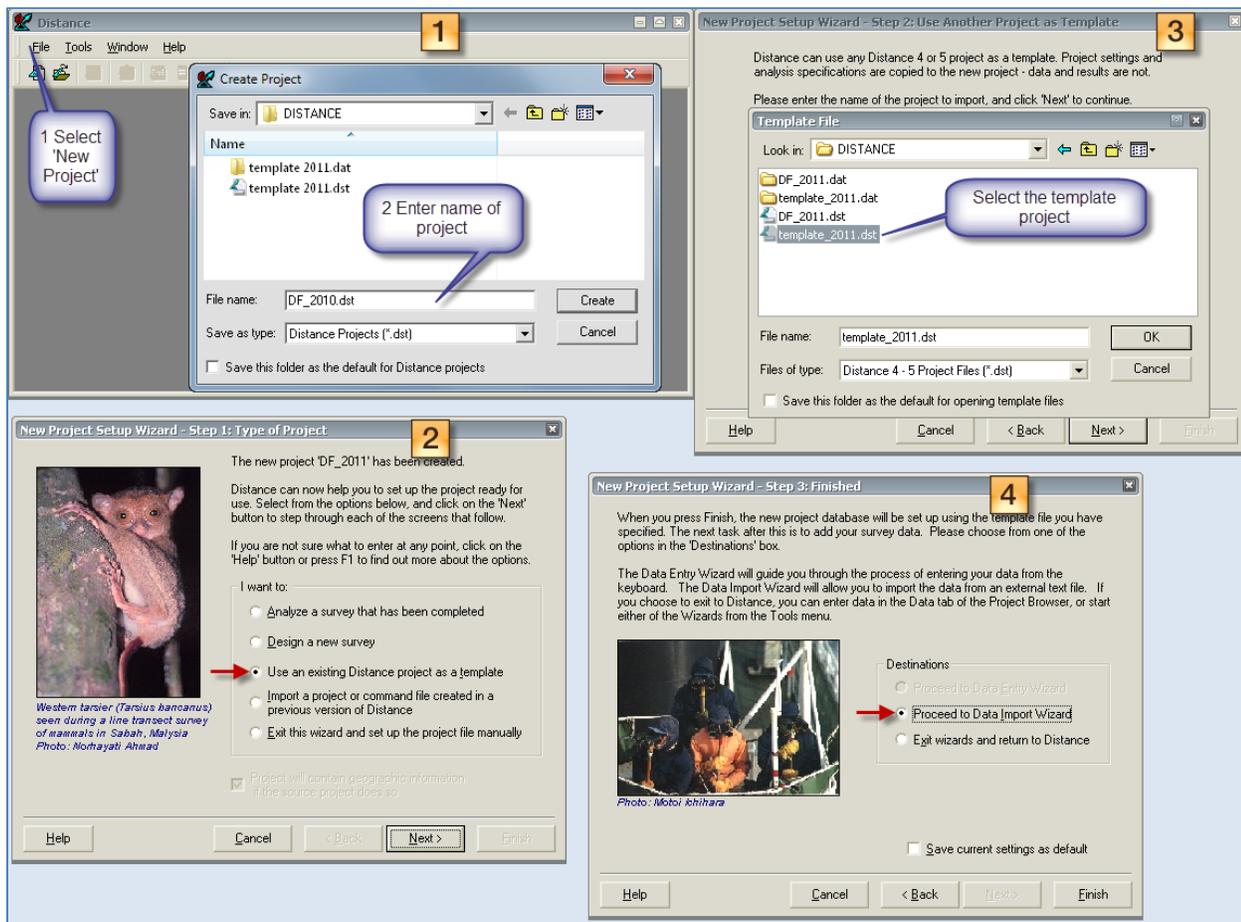


Figure SOP 11.11. Creation of a new project in the 'New Project Setup Wizard' of DISTANCE using a template project file to import pre-defined settings and analyses.

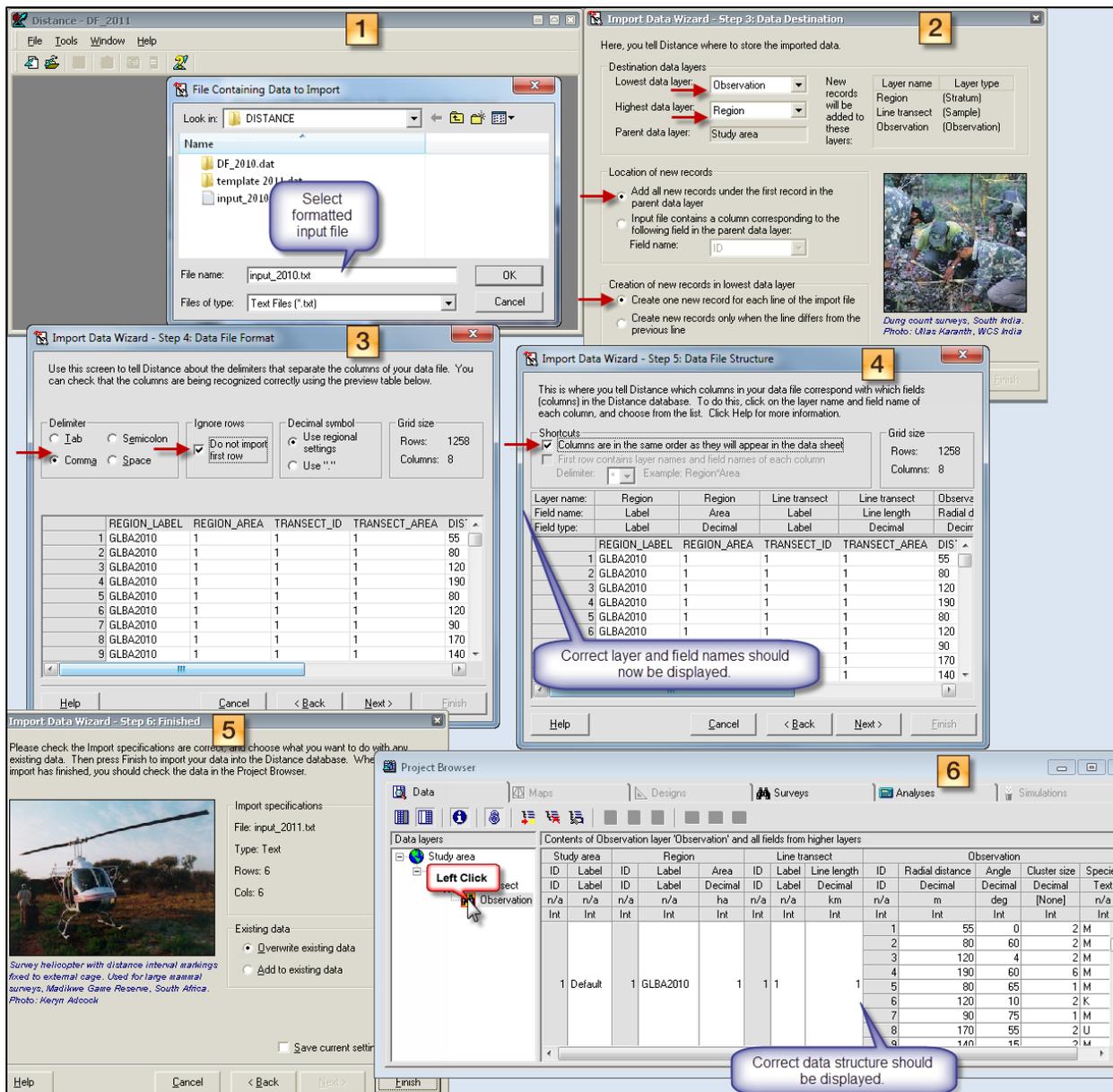


Figure SOP 11.12. Importing a formatted text file containing survey observation data using the 'Import Data Wizard'. Gold boxes indicate the sequence of steps; red arrows highlight user input. Upon completion, selecting the 'Observation' data layer in the 'Data' tab of the 'Project Browser' should display the imported data with correct layer names, field names, and data structure.

1 Select 'View|Project Browser'

2 Select the "Analyses" tab

3 Select 'Exploratory' from the drop down menu

ID	Name	# params	Delta AIC	AIC	ESW/EDR	D	D LCL	D UCL	D CV
1	Untruncated	4/27							
2	Truncated	4/2							
4	Truncated with Bins A	4/2							

4 Select the 'Untruncated' analysis

5 Left-click the 'Run' button

6 Right-click on the ID number and select 'Analysis Details'

2 Navigate results using 'Back/Next' or the drop down menu

1 Select the 'Results' tab

Detection Fct/Global/Plot: Detection Probability 1

Detection Probability

Perpendicular distance in meters

Inputs

Log

Results

Figure SOP 11.13. Displaying, executing, and displaying output from pre-defined analyses in the 'Exploratory' set.

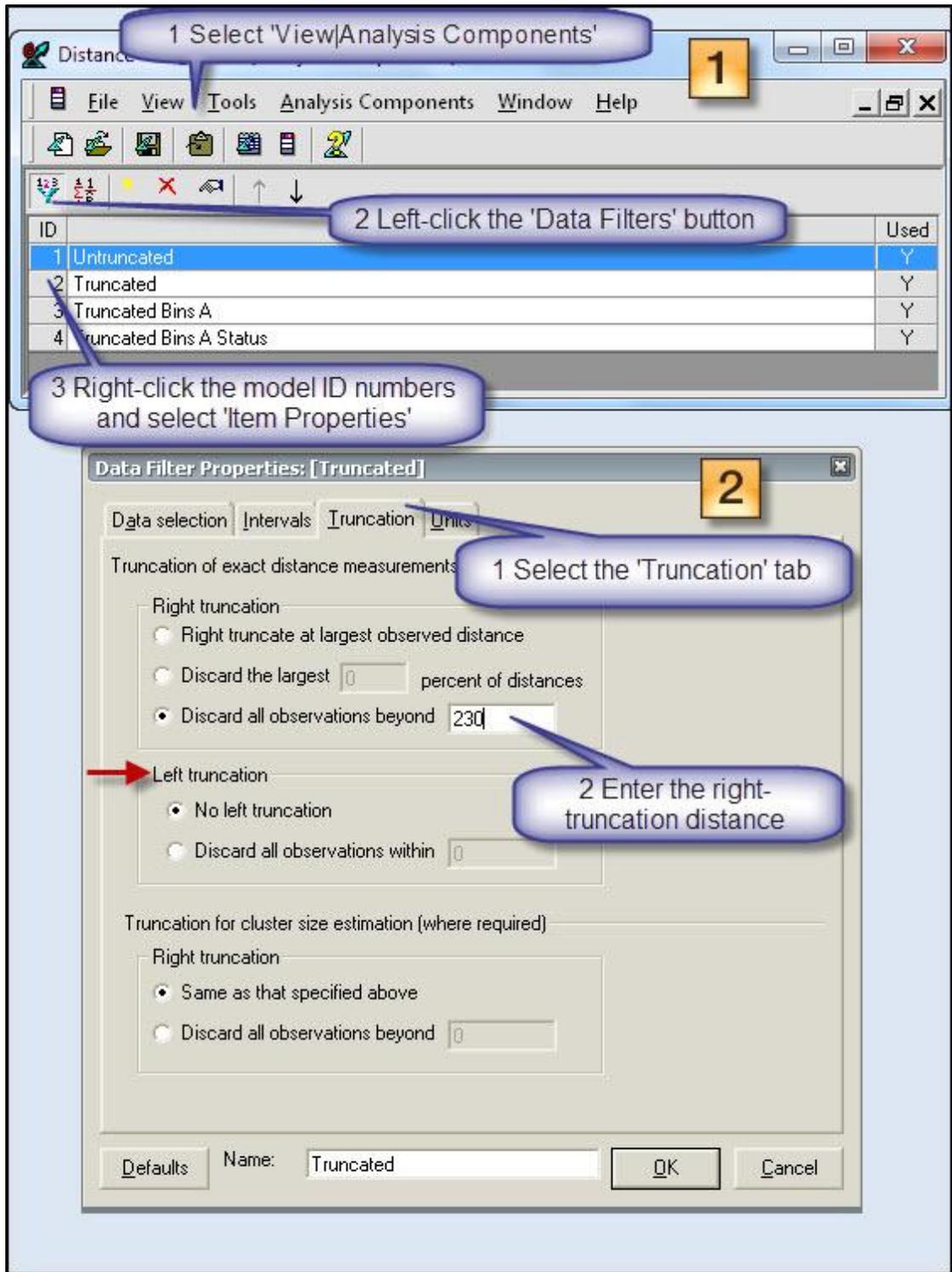


Figure SOP 11.14. Setting the right-truncation distance in the 'Data Filter properties' window. This setting should be applied to all 'Truncated' data filters.

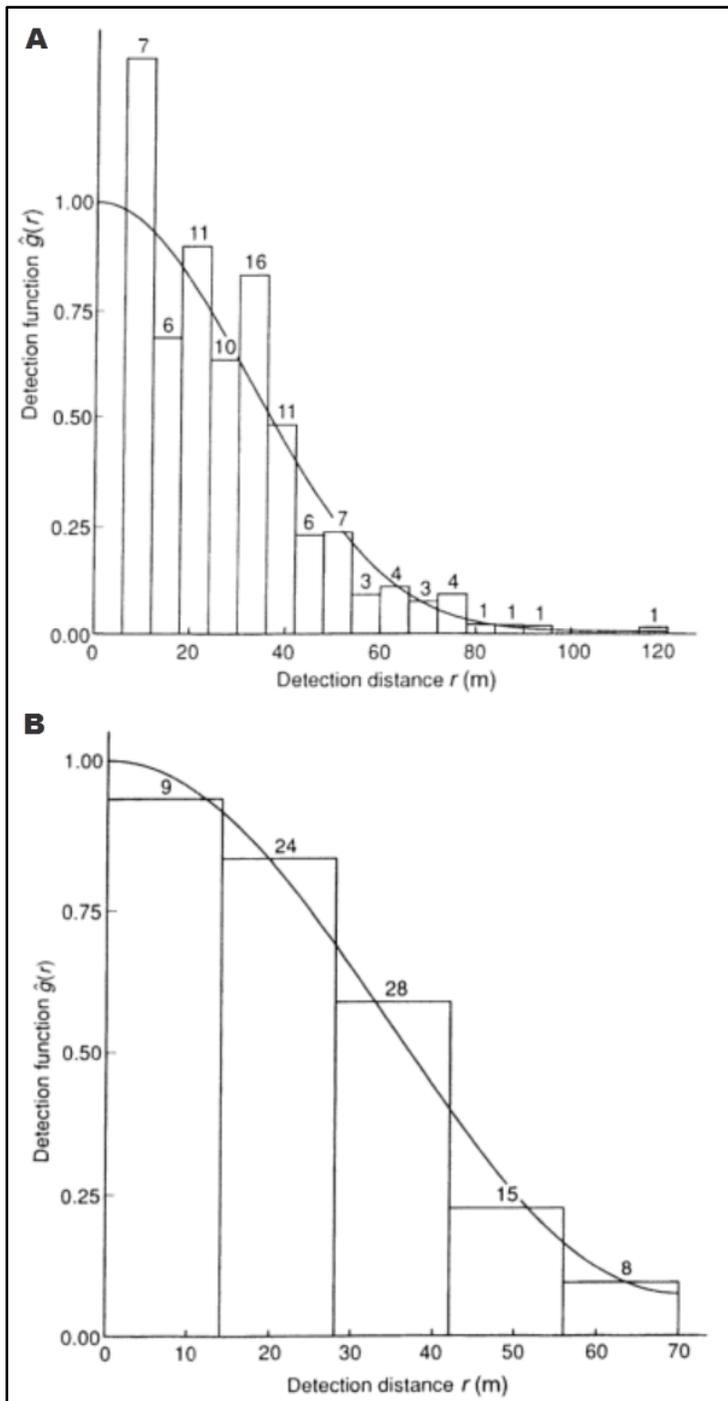


Figure SOP 11.15. Histograms (bars) showing frequency of detections (y-axis) relative to perpendicular distance from the transect center line (x-axis). Frequencies are scaled relative to estimated detection functions (lines); number of detections shown above bars. Untruncated data in relatively narrow bins (A) shows evidence of 'heaping' of observations at ~10, 20, and 30 m. Right-truncating and binning data by placing cut-points at mid-points between peaks (B) mitigates deleterious effects of heaping and helps meet shape criteria (Buckland et al. 2001).

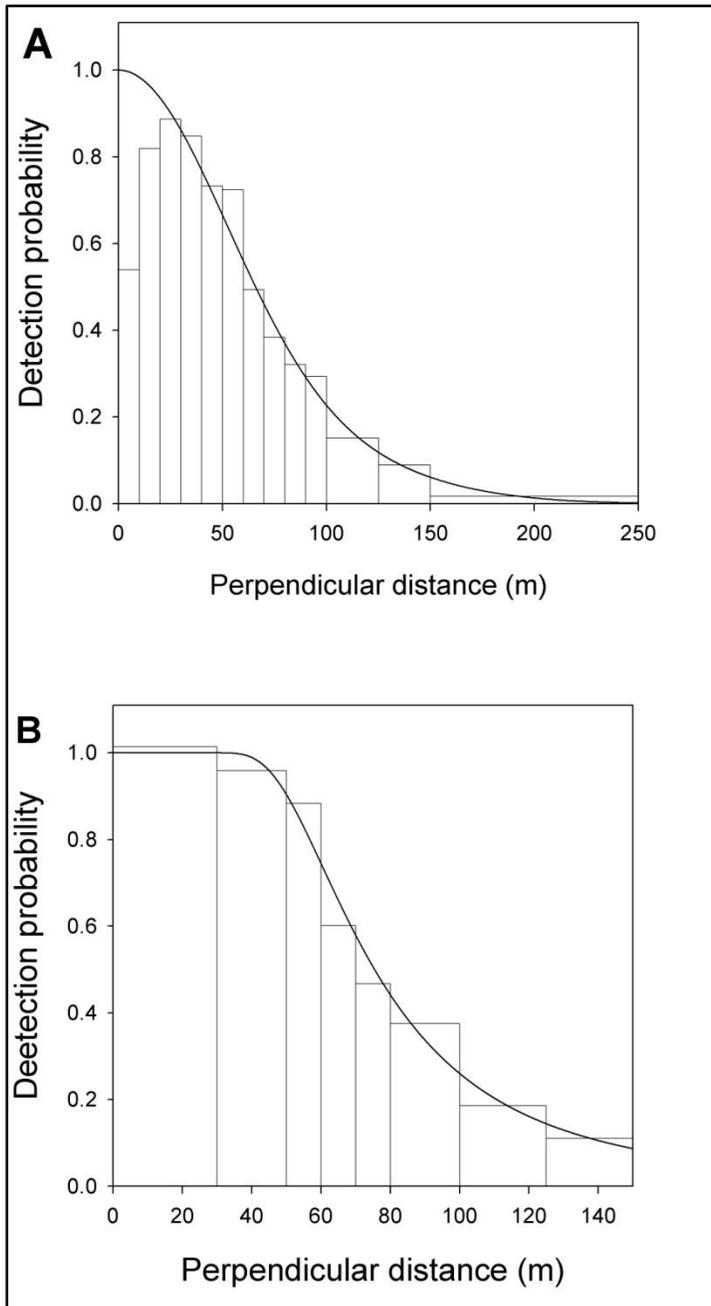


Figure SOP 11.16. Histograms (bars) showing frequency of detections (*y*-axis) relative to perpendicular distance from the transect center line (*x*-axis). Frequencies are scaled relative to estimated detection functions (lines). Untruncated data in relatively narrow bins (A) shows evidence of evasive movement (increasing frequencies from 0 to ~25 m). Right-truncating and binning data by creating a wide bin that 'captures' evading groups in the lowest distance bin improves the distribution by creating a stronger "shoulder" (slope ~0 at small distances) in the data distribution (Buckland et al. 2001).

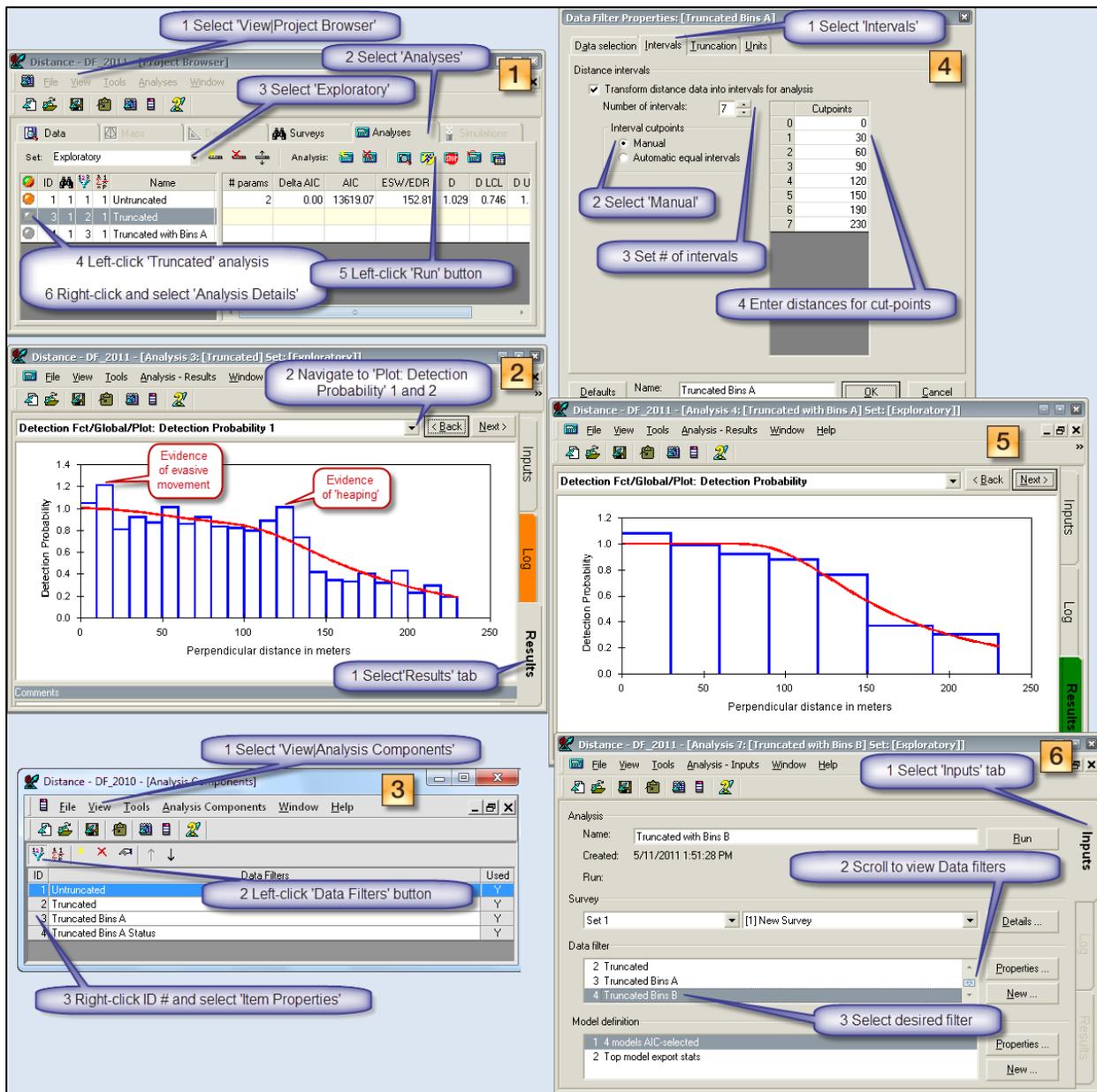


Figure SOP 11.17. Binning of survey observations by perpendicular distance from the transect center line. Distribution problems identified in exploratory analyses (1-2) may motivate binning data by distance for individual 'Data Filters' in the 'Analysis Components' window (3-4) to improve distributions (5). Alternative binning strategies can be compared by creating additional 'Data Filters' (6).

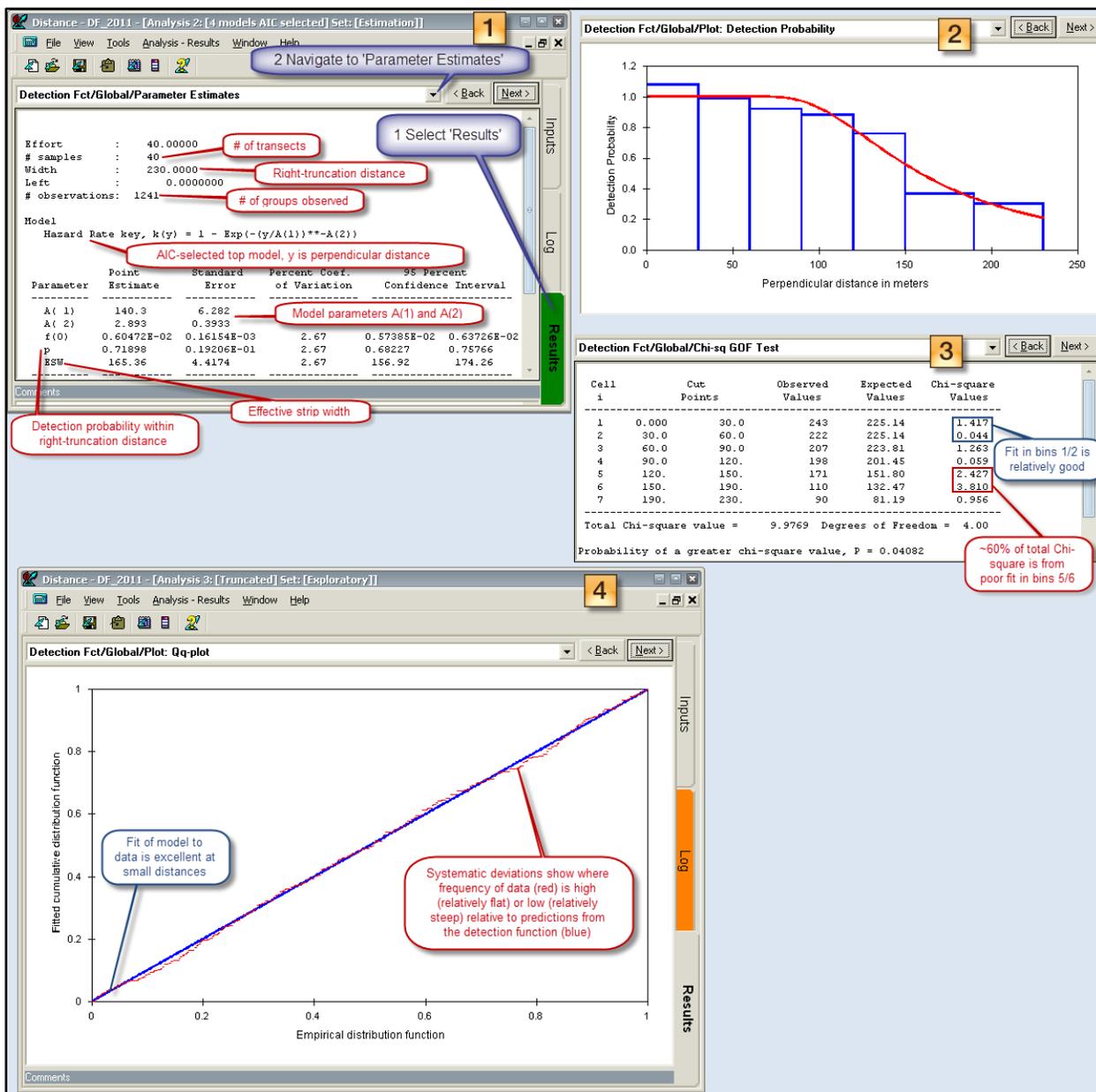


Figure SOP 11.18. Output from DISTANCE for an estimated detection function. The 'Parameter Estimates' window (1) shows samples, the AIC-selected top model, and quantitative output from this model. The 'Plot: Detection Probability' windows displays frequency data (blue) and the estimated detection function (2), and the 'Chi-sq GOF Test' window (3) contains the associated χ^2 goodness-of-fit test. For un-binned data, the q-q plot (4) displays of goodness-of-fit.

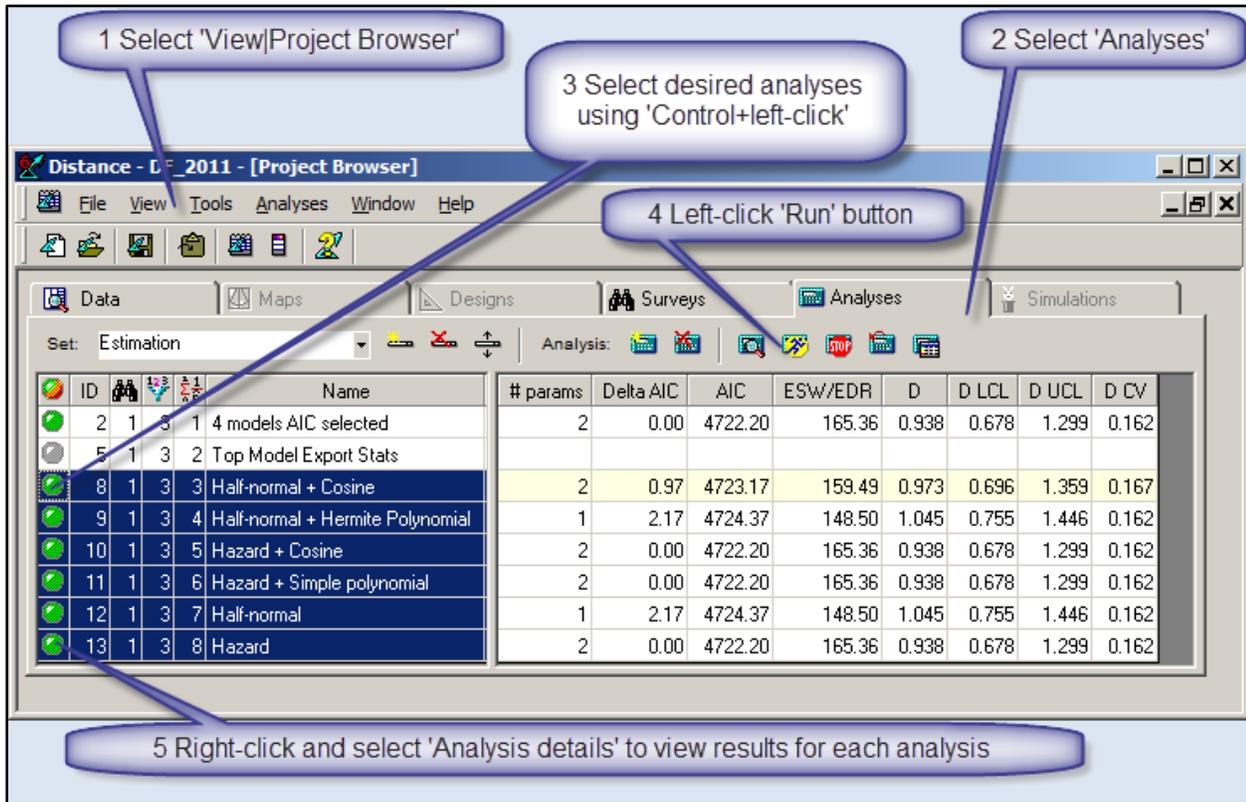


Figure SOP 11.19. Selecting, executing, and viewing results from analyses for individual detection function models. The 'Delta AIC' column gives differences in AIC values relative to the top model in the set (i.e., identical data and binning strategy).

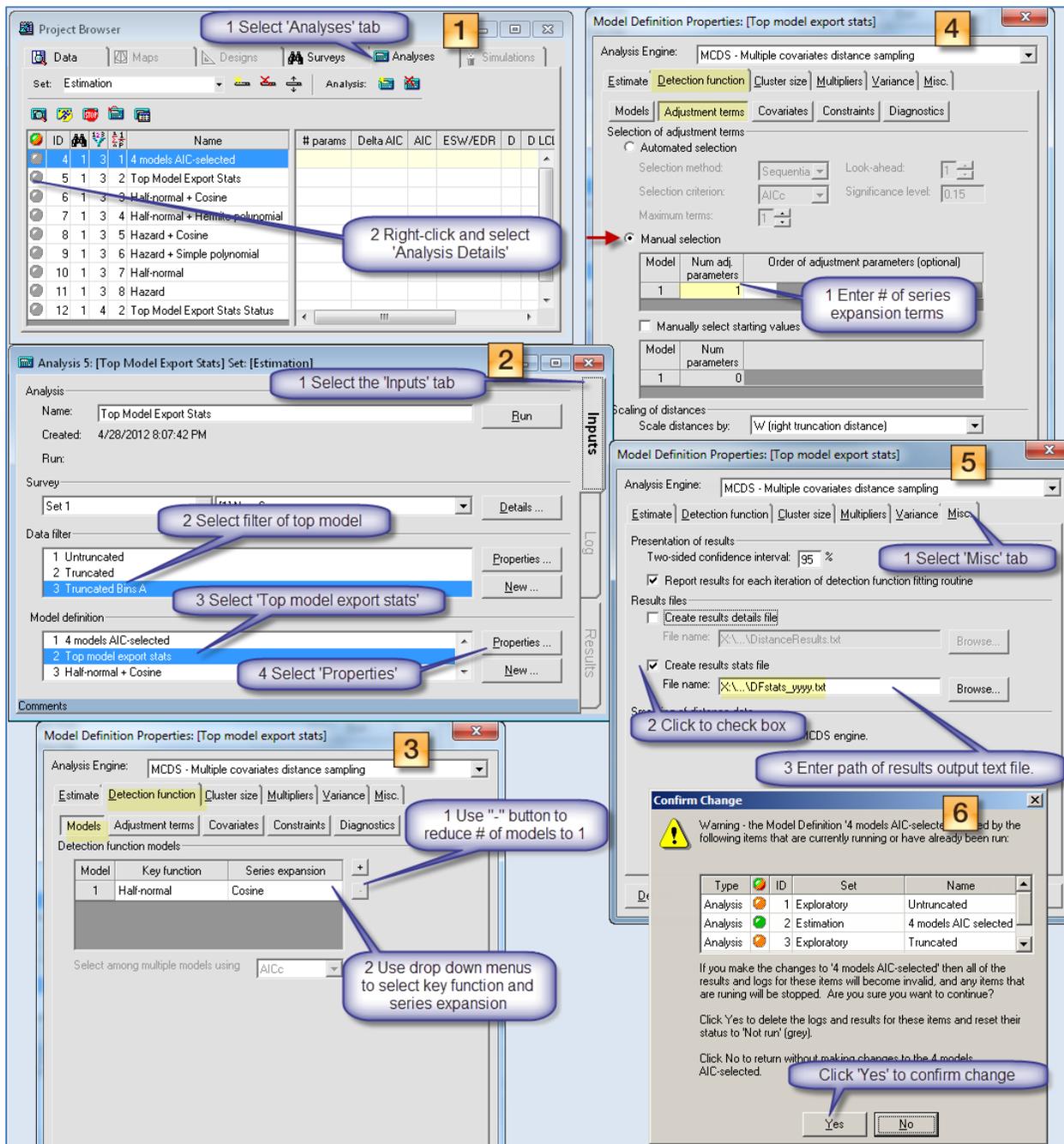


Figure SOP 11.20. Exporting the Program DISTANCE results stats file for the selected detection function model. After adding the path of the stats file to the 'Model Definition' for the analysis used to estimate the selected detection function model, execute the analysis to generate the file.

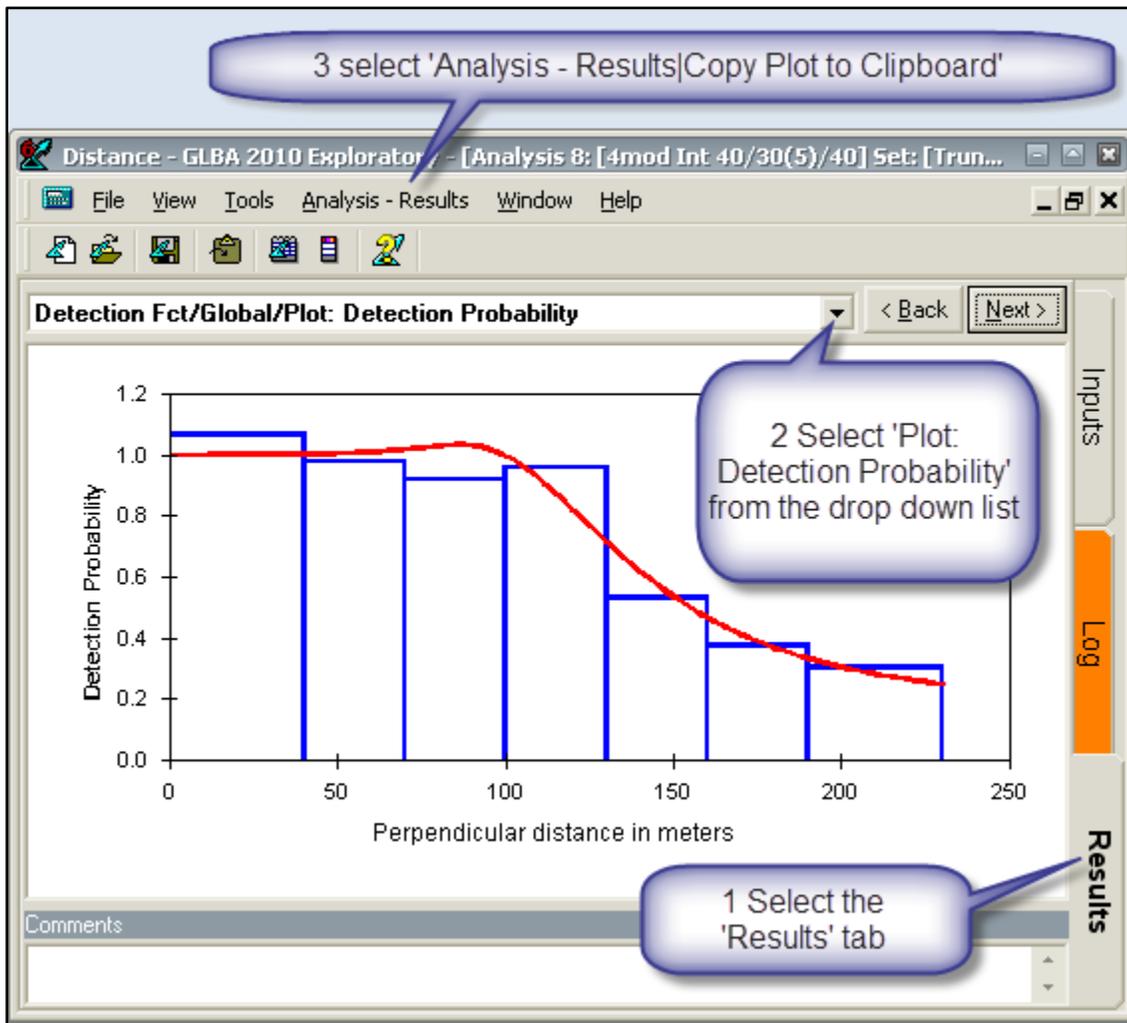


Figure SOP 11.21. Exporting a plot of a detection function from DISTANCE. The plot data are copied to the clipboard and then pasted into a text file.

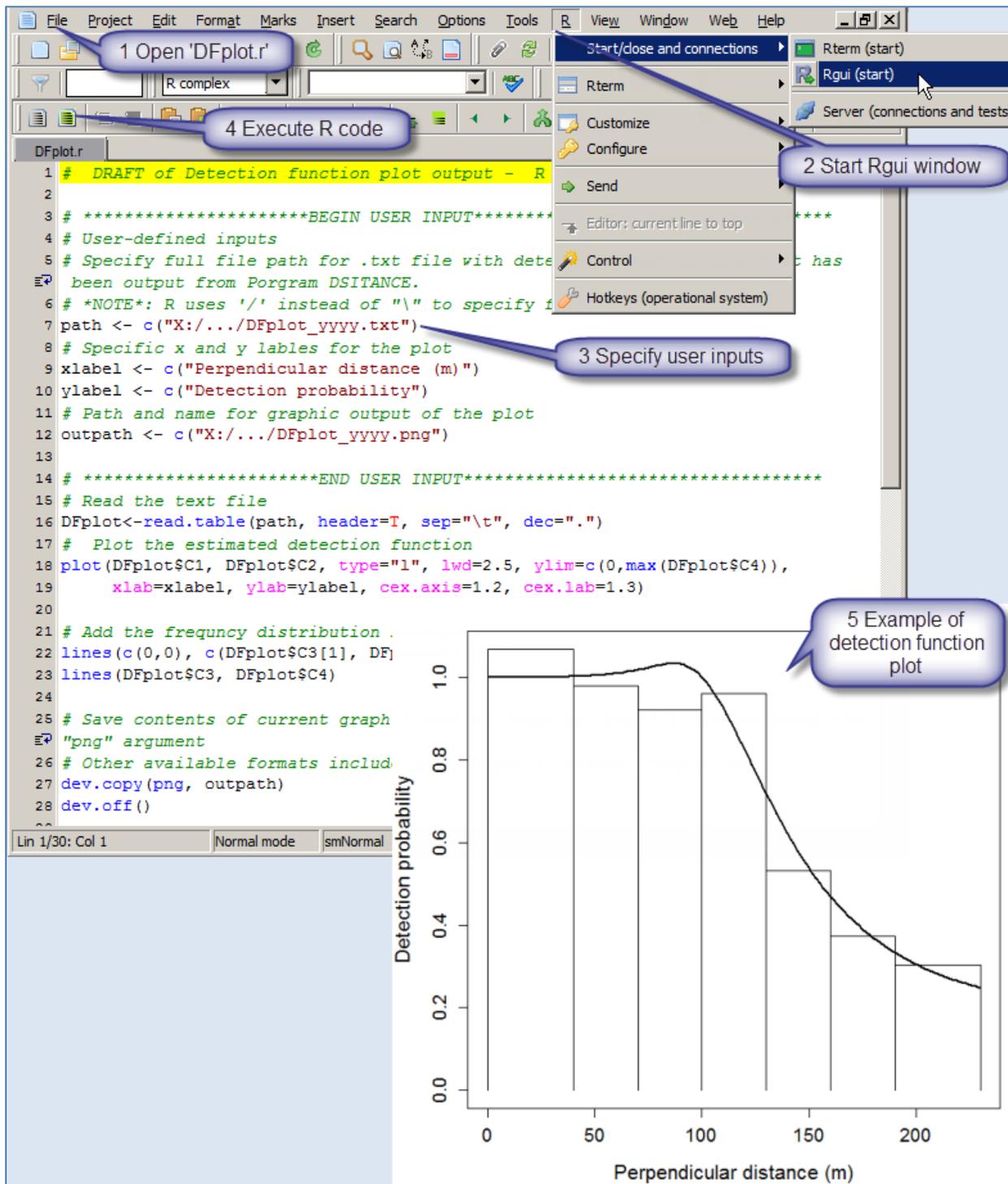


Figure SOP 11.22. Program R code used to produce an image of the estimated detection function and associated frequency data. Red text indicates user-specified inputs.

Table SOP 11.1. Data columns in input file of observation data for import to Program DISTANCE. Layer and field names in the first two columns specify hierarchical data naming structure applied within DISTANCE.

Program DISTANCE			Input file		Repository field source or specified value
Column	Layer name	Field name	Data type	Field name	
1	Region	Label	String	REGION_LABEL	GLBAyyyy ^a
2	Region	Area	Integer	REGION_AREA	1
3	Line transect	Label	Integer	TRANSECT_ID	TRANSECT_ID (Tbl_observation)
4	Line transect	Area	Integer	TRANSECT_AREA	1
5	Observation	Radial distance	Integer	DISTANCE	DISTANCE (Tbl_observation)
6	Observation	Angle	Integer	ANGLE	ANGLE (Tbl_observation) ^b
7	Observation	Size	Integer	GROUP_SIZE	GROUP_SIZE
8	Observation	Species	String	SPECIES	SPECIES (Tbl_observation) ^c

^aSurvey year is specified by yyyy.

^bAngle values recalculated as described at steps in A.3.f in the 'Data Import to DISTANCE' section.

^c"K" = KIMU, "M" = MAMU, "U" = UNMU.

Table SOP 11.2. Pre-defined DISTANCE analyses used in exploratory analyses, estimation of a detection function, and estimation of group size.

Analysis set	Analysis name	Right-truncation	bins	Data filter	Model definition
Exploratory	Untruncated	N	N	Untruncated	4 models AIC-selected
Exploratory	Truncated	Y	N	Truncated	4 models AIC-selected
Exploratory	Truncated with bins A	Y	Y	Truncated bins A	4 models AIC-selected
Estimation	4 models AIC selection	Y	Y	Truncated bins A	4 models AIC-selected
Estimation	Top Model Export Stats	Y	Y	Truncated bins A	Top model export stats
Estimation	Half-normal+Cosine	Y	Y	Truncated bins A	Half-normal+Cosine
Estimation	Half-normal+Hermite polynomial	Y	Y	Truncated bins A	Half-normal+Hermite polynomial
Estimation	Hazard+Cosine	Y	Y	Truncated bins A	Hazard+Cosine
Estimation	Hazard+Simple polynomial	Y	Y	Truncated bins A	Hazard+Simple polynomial
Estimation	Half-normal	Y	Y	Truncated bins A	Half-normal
Estimation	Hazard	Y	Y	Truncated bins A	Hazard
Estimation	Top Model Export Stats Status	Y	Y	Truncated bins A Status	Top model export stats

Table SOP 11.3. Key to codes for specification of output related to estimated detection functions and group size from the DISTANCE results files (e.g., “DFstats_yyyy.txt” and “DFstats_yyyy.csv”) . Output content in each row is coded by values in the 4th and 5th columns.

Output	ID code values by column				Values from file			
	Col 1	Col 2	Col 4	Col 5	Col 6 ^a	Col 7 ^b	Col 10 ^c	SE ^b
Right-truncation distance	0	0	1	6	value			
Detection probability within right-truncation distance	0	0	2	5	estimate	CV	df	col6-col7
Effective strip width	0	0	2	6	estimate	CV	df	col6-col7
Key function	0	0	2	13	integer ^d			
Series expansion	0	0	2	14	integer ^e			
# key function parameters	0	0	2	15	value			
# series expansion parameters	0	0	2	16	value			
Parameter estimates for detection function	0	0	2	101...	estimate	CV	df	col6-col7
Parameter estimate for average group size	integer ^f	Y/N ^g	3	1	estimate	CV	df	col6-col7
P-value for group size regression	integer ^f	0	3	3	value			
Parameter estimate for expected group size from regression	integer ^f	Y/N ^g	3	4	estimate	CV	df	col6-col7

^aAll are floating point numeric, except those specified as integer.

^bFloating point numeric

^cInteger

^d1 = uniform, 2 = half-normal, 3 = negative exponential, 4 = hazard rate

^e0 = no series expansion 1 = simple polynomial, 2 = Hermite polynomial, 3 = cosine

^f1 = KIMU, 2 = MAMU, 3 = UNMU

^gY = estimate selected for density/abundance analyses, N = estimate not selected for density/abundance analyses. Column 2 is manually edited by the Project Leader (see step A.3 in the ‘Estimating Group Size Using DISTANCE’ section for additional detail).

Appendix SOP 11.A: R code for plotting detection functions

```
# Detection function plot output - R statistical computing environment code

# *****BEGIN USER INPUT*****
# User-defined inputs
# Specify full file path for .txt file with detection function data that has been output
from Program DISTANCE.
# *NOTE*: R uses '/' instead of "\" to specify file paths.
path <- c("\\inpglbafs03\data\SEAN_data\Work_zone\KM\KM_J\yyyy\DFplot_yyyy.txt")
# Specific x and y labels for the plot
xlabel <- c("Perpendicular distance (m)")
ylabel <- c("Detection probability")
# Path and name for graphic output of the plot
outpath <- c("\\inpglbafs03\data\SEAN_data\Work_zone\KM\KM_J\yyyy\DFplot_yyyy.png")

# *****END USER INPUT*****
# Read the text file
DFplot<-read.table(path, header=T, sep="\t", dec=".")
# Plot the estimated detection function
plot(DFplot$C1, DFplot$C2, type="l", lwd=2.5, ylim=c(0,max(DFplot$C4)),
      xlab=xlabel, ylab=ylabel, cex.axis=1.2, cex.lab=1.3)

# Add the frequency distribution histogram
lines(c(0,0), c(DFplot$C3[1], DFplot$C4[1]))
lines(DFplot$C3, DFplot$C4)

# Save contents of current graph window as image in .png file format using the "png"
argument
# Other available formats include jpeg ("jpeg"), bitmap ("bmp"), etc.
dev.copy(png, outpath)
dev.off()
```

SOP 12: Abundance Estimation (KM_K Creation)

Version 1.0

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
	November 2012	S. Hoekman, W. Johnson, B. Moynahan, C. Sergeant	Initial version		1.0

Summary

The certified versions of the “KM_E: Cumulative observation database” and “KM_J: Detection function” deliverable for the current survey year are used to estimate species-specific, on-water density and abundance within the survey area. Using software code for the R statistical package provided in Appendix D, the user specifies data inputs and then executes code to produce estimates of encounter rates, density, and abundance for use in reports and analyses of population status and trend. Output from the R code is appended to “KM_K: Abundance estimates” deliverable.

This protocol employs the R software package for statistical computing, freely available at <http://www.r-project.org/>. We also recommend use of an external editor to manage and execute the R code provided in Appendix D. Program TINN-R is a suitable graphical user interface and editor for the R programming language. Information about this software is available at <http://www.sciviews.org/Tinn-R/> and the software is freely available at <http://sourceforge.net/projects/tinn-r/>.

We selected survey transects using a two-stage procedure (see Appendix B, section B.7). The first stage employed probabilistic methods of sample selection, and these sampling probabilities were used to appropriately weight estimates for analyses of population status (see Appendix A, section A.3). The second stage added one transect to the survey sample via non-probabilistic methods; hence, this transect is appropriate for analyses of population trend but not status. Output from this SOP separates results for analyses of population status versus population trend.

Data inputs for population analyses are the estimates produced in Program DISTANCE as described in SOP 11 (detection probability across the transect width, probability of detection near the transect center line, group size for KIMU, MAMU, and unidentified murrelets, and the transect strip width) and the corrected survey transect data from “KM_E: Cumulative observation database” deliverable (groups of KIMU, MAMU, and unidentified murrelets encountered on the water on survey transects, transect length, selection probability for transects, latitude and longitude of mid-points of transects). Estimation methods (described in Appendix A) account for detection probability, incomplete species identification, uneven allocation of sampling intensity, the spatially-balanced sampling design, and clumped distributions of murrelet populations. Output from this SOP includes estimates and associated measures of uncertainty for: encounter rates (groups/km) for KIMU, MAMU, and unidentified murrelets, species-specific adjusted encounter rates

(accounting for unidentified murrelets), and species-specific density (individuals/km²) and abundance (across the survey area) accounting for unidentified murrelets.

Creation of Input Files

The Data Manager creates two comma delimited text files for import into R. The file "Encounter_Rates_YYYY.csv" (where YYYY is the survey year) is created from KM_E: Cumulative observation database deliverable and will summarize encounter rates of murrelet groups on each transect as well as transect attributes for the current survey year (Table SOP 12.1). The file "DISTANCE_Ouput_YYYY.csv" (where YYYY is the survey year) is created from KM_J: Detection Function deliverable and summarizes estimates of detection probability and group size for murrelets from Program DISTANCE for the current survey year (Table SOP 12.2).

Detailed Steps

A. Data Manager Tasks

1. Produce a text file summarizing encounter rates and transect attributes for the current survey year.
 - a. Be certain the KM_E and KM_J deliverables are certified for the year of interest – the file is created from their content.
 - b. Connect to the data management web site (currently [\\165.83.57.239](http://165.83.57.239)) and log in using your Windows userid and password – userid must be of the form "username@NPS".
 - c. Under Kittlitz's Murrelets, click on the KM_K task called "Create input table SOP 12.1".
 - d. Specify the year of interest from the dropdown.
 - e. The right truncation distance reflected in KM_J is shown as the default to use. An analyst may choose to enter another value over this default.
 - f. Press the button to preview a sample result on screen if desired.
 - i. The file should contain one row for each transect surveyed (transects with no encounters must be included an encounter rate of 0, with nine fields as described in Table SOP 12.1.
 - ii. Each scheduled transect that was not surveyed at all should appear with null (not zero) for transect distance and the four encounter rates.
 - g. Press the button to save complete results to "[\\inpglbafs03\data\SEAN_data\Work_zone\KM\KM_K\YYYY\Encounter_rates_YYYY.csv](file://inpglbafs03\data\SEAN_data\Work_zone\KM\KM_K\YYYY\Encounter_rates_YYYY.csv)" where YYYY is the four-digit survey year.
2. Produce a text file summarizing estimates of detection probabilities and group sizes.
 - a. Be certain the KM_J deliverable is certified for the year of interest and the "Update database with certified KM_J" data management task has successfully completed – the file is created from this content.
 - b. Connect to the data management web site (currently [\\165.83.57.239](http://165.83.57.239)) and log in using your Windows userid and password – userid must be of the form "username@NPS".
 - c. Under Kittlitz's Murrelets, click on the KM_K task called "Create input table SOP 12.2".
 - d. Specify the year of interest from the dropdown.

- e. The timestamp that the year's content was put in the database appears. Be certain it is in the appropriate range.
- f. Press the button to preview a sample result on screen if desired.
 - i. The file must contain one row with 25 fields as described in Table SOP 12.2.
 - ii. Estimates of detection probability near the transect center line (P_c) are taken from results of field experiments (see Appendix A, section A.2). These must have been already stored in the one-row database table named `tbl_detection_centerline`.
 - iii. Transect width (w ; aka 'the right-truncation distance') is selected during preliminary analyses (see SOP 11).
 - iv. All other fields are estimates from Program DISTANCE (see SOP 11).
 - v. Because not all transects are appropriate for population status estimates (see Appendix B, section B.7), separate attributes hold estimates of group size for population trend and status.
- g. Press the button to save complete results to [“\\inpglbafs03\data\SEAN_data\Work_zone\KM\KM_K\yyyy\DISTANCE_Output\yyyy.csv”](#) (where yyyy is the survey year).

Executing R Code

The Project Leader opens the R code from Appendix D in Program TINN-R or another text editor. In the user-defined input section, the Project Leader species the input files and other parameters for analyses. Execution of the code in R produces estimates of abundance and related parameters, which are displayed via the R console and exported to a database file.

Detailed Steps

A. Project Leader Tasks

1. Install required R package: MASS (if not previously installed)
 - a. Start TINN-R and open an R GUI console using the 'R|Start/close and connections|R GUI (start)' file menu command.
 - b. In the R console window, use the 'Packages|Set CRAN mirror' file menu command to select from a list of available mirrors.
 - c. Use the 'Packages|Install package(s)' menu command to open a window with available packages. Navigate to and select the "MASS" package to install it.
2. Open the R code for abundance analyses
 - a. Start TINN-R and open an R GUI (graphical user interface) console using the 'R|Start/close and connections|R GUI (start)' file menu command.
 - b. In the TINN-R window, use the "File|Open" menu command to select the R file containing code from Appendix D ([“//inpglbafs03/data/SEAN_Data/Work_Zone/KM/KM_K/APPENDIX_D.r”](#)).
 - c. The code should be displayed as a tabbed window in the text editor.
3. Specify user-defined inputs

- a. Navigate to the top of the file. The first section headed "BEGIN USER INPUT" should be displayed, showing attributes of the analyses defined by the user (Figure SOP 12.1).
 - b. Save your working file under a new name using the 'File|Save as' menu command.
 - c. Specify the full path of the working folder containing input files created by the Data Manager (see section 1, above) and where output will be placed using the 'path' input. Note: R requires forward slashes "/" in the file path, rather than the back slashes "\" used in the Windows operating systems.
 - d. Provide names of the input files containing output from Program DISTANCE and the encounter rate data for the current survey year.
 - e. Specify the 4-digit survey year.
 - f. The area in km² for projection of abundance estimates can be specified by the user at the 'A' input, but typically projection over the area of the survey area (1,170 km²) will be desired.
 - g. Specify the desired % for confidence interval coverage in percent at the 'CI' input. The default is 95% CI coverage.
 - h. Other user-defined inputs specify characteristics of the sample of survey transects and are unlikely to change unless the survey design is altered.
 - i. The 'panels' input specifies the number of survey transect panels (i.e., 1 permanent + 3 alternating panels).
 - ii. The 'plim' input specifies the range of acceptable transect ID numbers.
 - iii. The 'coordlim' input specifies the range of acceptable latitude and longitude coordinate values in decimal degrees for transect mid-points.
 - iv. The 'xstatus' input specifies the ID numbers of transects selected using non-probabilistic methods and hence to be excluded from population status analyses.
 - i. Save the file using the 'File|Save' menu command to preserve user-defined inputs.
4. Execute analyses
- a. Execute analyses using the "R|Send|File" menu command or by clicking the equivalent button on the R toolbar (Figure SOP 12.2) to send the code to the R console.
 - b. If successful, output from analyses should be displayed in 2 tables in the R console window (Figure SOP 12.3): one for population trend analyses and one for population status analyses.
 - c. Output will also be written to an ACSII CSV text file "R_Output_YYYY.csv", where YYYY is the survey year. The file will be formatted as shown in Table SOP 12.3 and output to the folder specified above in step 3.c.
 - d. Estimates should be carefully checked to make sure that output is consistent with data inputs and prior results and that all required fields are non-null and that field values are within permissible ranges (Table SOP 12.3).
 - e. If unsuccessful, the R console window likely will display an error message(s).
 - f. The R code checks for deficiencies in the structure and values of the input files; error messages from these checks should indicate the nature of the deficiency.

- g. Otherwise, error messages generated by R may help identify the nature of the error preventing code execution.
- h. Make corrections to the files used in this process and re-execute the R code until the output is acceptable.

Formally validate and certify the final product

The SEAN data management plan requires all monitoring deliverables be formally validated against rules defined in the protocol. When all mandatory criteria have been met, the Project Leader may declare them certified in writing. Once certified, the Data Manager must install them in repositories and attach them to electronic dissemination services.

Detailed Steps

A. Project Leader Tasks

1. Request validation by sending a notification email to the Data Manager, specifying in the message body that deliverable KM_K, for year yyyy is ready; the Data Manager will know where to find the file named "R_Output_YYYY.csv".

B. Data Manager Tasks

1. On receipt of the submission, assign the next formal Submission Number to this file, as found in the master Submission_Log table.
 - a. Use the "Update Submission Log" web tool at http://165.83.57.239/0_submission_update.aspx.
 - b. Complete Submission_Log details up through the Submission_Date column.
2. Copy the R_Output_YYYY.csv file into the staging area for validation at a subdirectory named with the submission number in \\inpglbafs03\data\SEAN_Data\Staging\KM\KM_K. Rename the file to KM_K_YYYY.csv
3. Validate the submission according to the current criteria.
 - a. Invoke validation of the CSV file according to current criteria by using the web program at http://165.83.57.239/KM_DM_validate_KMK.aspx.
 - b. Validation summary results automatically are recorded in the Submission_Log.
4. If submission fails any mandatory criteria, reply with a "failure email" that includes:
 - a. The submission number assigned
 - b. The deliverable ID
 - c. The protocol ID
 - d. Documentation listing all the criteria failed
5. If submission passes mandatory criteria, reply with a "success email" that includes:
 - a. The submission number assigned
 - b. The deliverable ID
 - c. The protocol ID
 - d. Documentation listing any specific optional criteria failed
 - e. Request to certify deliverable as complete

C. Project Leader tasks

1. On receipt of a failure email:

- a. Review the validation report and remedy the mandatory errors by revising the output file.
- b. Initiate a new submission with the Data Manager.
2. On receipt of a success email, review any failed optional criteria:
 - a. If the criteria review indicates the validated data are acceptable:
 - i. Reply with a "certification email" stating the deliverable is certified and may be disseminated.
 - b. If the validated data are unacceptable:
 - i. Reply with a "withdrawal email", stating the deliverable is withdrawn.
 - ii. Take remedial action to obtain and resubmit a corrected deliverable, if possible.

D. Data Manager Tasks

1. On receipt of a withdrawal email:
 - a. Mark the withdrawal in the Submission_Log's Status column using the web tool.
 - b. Terminate the process.
2. On receipt of a certification email:
 - a. Verify no sensitive information is in the deliverable. Products containing sensitive information cannot be disseminated. If sensitive:
 - i. Mark the sensitive designation in the log's submission status column using the web tool.
 - ii. Notify the submitter of the situation.
 - iii. Complete the deliverable tracking spreadsheet cells referring to dissemination with the word SENSITIVE.
 - iv. Do not attempt to install the sensitive item in the database.
 - v. Terminate the process.
 - b. Use the "Update Submission Log" web tool at http://165.83.57.239/0_submission_update.aspx to mark the submission as certified.
 - i. Set status to "C".
 - ii. Set certification date to date of the certification email.
 - iii. Set certified by to the initials of the project lead.
 - iv. Mark any previously certified KM_K for that submission unit as decertified.
 - c. Update the staging database to reflect the new revised abundance estimates by invoking the web program at http://165.83.57.239/KM_K_update_db_DM.aspx.
 - i. The application will revalidate the CSV file.
 - ii. If validation fails, remediate the issue.
 - d. Test accessibility to updated data from Integration web site until successful.
 - e. Propagate from staging to production database.
 - f. Verify final deliverable is accessible from production web site.
 - g. Update the deliverable tracking spreadsheet milestones with the date of completion for KM_K. The sheet is kept in development's \AuxRep\KM directory.
 - h. Update the scope of the formal metadata so it includes this new date range.

SOP 12 Figures and Tables

```

Abundance estimator v0.993.r*
4 # *****BEGIN USER INPUT*****
5 # Annual user-defined inputs
6
7 # Specify full path for folder to contain input and output files.
8 # *NOTE*: R uses '/' instead of "\" to specify file paths, and path must be in "quotes".
9
10 path<- "C:/.../Protocol Analyses/2012/"
11
12 # Specify file names for .csv input files with encounter rate data (as specified in SOP 12, Table 12
13 # .1) and output from Program DISTANCE (as specified in SOP 12, Table 12.2). File name must be in
14 # "quotes".
15 Encounter.Rate.file <- "Encounter_rates_2012.csv"
16 DISTANCE.Output.file <- "Distance_Output_2012.csv"
17
18 # Specify 4-digit survey year. A comma-delimited file with output named "abundance_yyyy.csv" (where
19 # yyyy is the survey year) will be created in the folder specified above.
20 YEAR<-2012
21
22 # Most user-defined inputs below will be invariant among years
23
24 # Desired area for projection of abundance in square km
25 A<-1170
26
27 # Desired confidence interval coverage for abundance estimates in %
28 CI<-95
29
30 # Ranges for TRANSECT_ID: set lower/upper limits for each panel
31 # panels = Number of panels
32 # plim = Lower and upper limits of TRANSECT_ID numbers for each panel ascending from panel 0
33 panels <- 4
34 plim <- c(1, 25, 100, 115, 200, 221, 300, 321)
35
36 # Min/Max values for latitude and longitude of transect midpoints
37 # coordlim = min lat, max lat, min lon, max lon
38 coordlim <- c(58, 59.5, -137.5, -135.5)
39
40 # Transect_ID number(s) for survey transects to be excluded from population status estimates
41 xstatus<- c(16)

```

Figure SOP 12.1. User input area in Program R code for estimation of density and abundance, displayed in the Tinn-R text editor. Red arrows indicate lines where user input is provided to the right of the '<-' operator. The folder path for data import and export is specified in line 10, and names of input files containing data for import into R are specified in lines 14 and 15. Results of analyses are exported in the file "R_Output_yyyy.csv", where yyyy is the survey year specified in line 19. Other user input typically will be invariant.

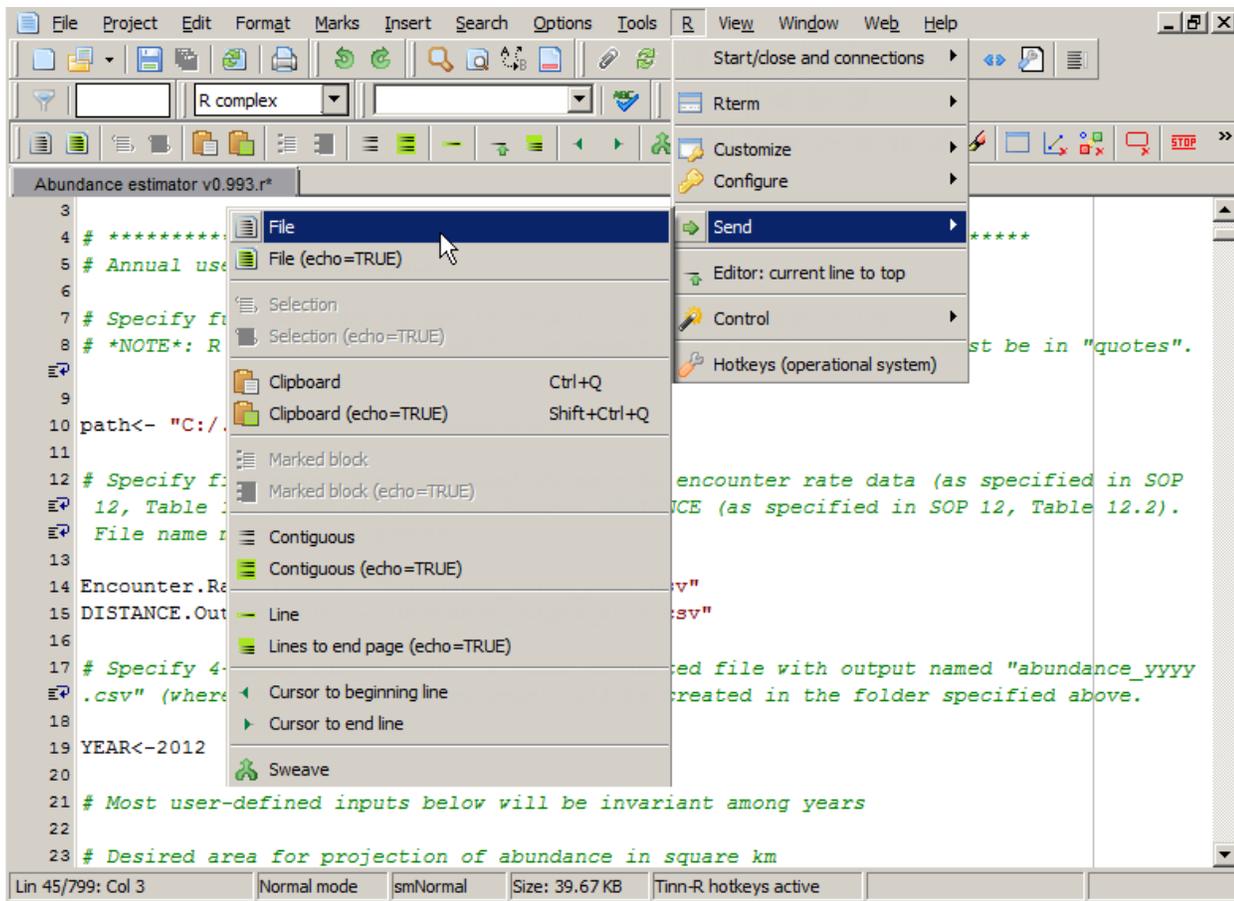


Figure SOP 12.2. After specifying user inputs and opening the R GUI console, send the code in the text editor to R using the 'R|Send|File' menu command or using the equivalent menu button indicated by the red arrow.

```

R Console (64-bit)
File Edit Misc Packages Windows Help

> source(.trPaths[4])
[1] "Estimates for Population Trend Analyses"
, , Encounter Rates

      Estimate SE var n df 95% lower CL 95% upper CL
Brachyramphus  7.18 0.75 0.57 40 39      5.71      8.66
Kittlitz's     1.11 0.20 0.04 40 39      0.73      1.50
Marbled        4.48 0.59 0.35 40 39      3.33      5.63
Unknown        1.59 0.14 0.02 40 39      1.32      1.85

, , Adjusted Encounter Rates

      Estimate SE var n df 95% lower CL 95% upper CL
Brachyramphus  NA   NA   NA NA NA      NA      NA
Kittlitz's     1.43 0.24 0.06 40 39      0.95      1.91
Marbled        5.75 0.71 0.50 40 39      4.36      7.14
Unknown        NA   NA   NA NA NA      NA      NA

, , Density

      Estimate SE var n df 95% lower CL 95% upper CL
Brachyramphus  NA   NA   NA NA NA      NA      NA
Kittlitz's     10.33 1.87 3.51 NA 49.00      7.26     14.70
Marbled        50.66 6.58 43.35 NA 47.35     39.31     65.28
Unknown        NA   NA   NA NA NA      NA      NA

, , Abundance

      Estimate SE var n df 95% lower CL 95% upper CL
Brachyramphus  NA   NA   NA NA NA      NA      NA
Kittlitz's     12090.6 2192.69 4807885 NA 49.00     8498.17 17201.65
Marbled        59267.0 7703.59 59345373 NA 47.35    45987.08 76381.83
Unknown        NA   NA   NA NA NA      NA      NA

[1] "Estimates for Population Status Analyses"
, , Encounter Rates

      Estimate SE var n df 95% lower CL 95% upper CL
Brachyramphus  7.19 0.75 0.57 39 38      5.70      8.66
Kittlitz's     1.11 0.20 0.04 39 38      0.73      1.50
Marbled        4.49 0.59 0.35 39 38      3.33      5.63
Unknown        1.59 0.14 0.02 39 38      1.32      1.85

, , Adjusted Encounter Rates

      Estimate SE var n df 95% lower CL 95% upper CL
Brachyramphus  NA   NA   NA NA NA      NA      NA
Kittlitz's     1.43 0.24 0.06 39 38      0.95      1.91
Marbled        5.76 0.71 0.50 39 38      4.37      7.15
Unknown        NA   NA   NA NA NA      NA      NA

, , Density

      Estimate SE var n df 95% lower CL 95% upper CL
Brachyramphus  NA   NA   NA NA NA      NA      NA
Kittlitz's     10.34 1.88 3.53 NA 47.98      7.26     14.72
Marbled        50.91 6.61 43.68 NA 46.18     39.52     65.59
Unknown        NA   NA   NA NA NA      NA      NA

, , Abundance

      Estimate SE var n df 95% lower CL 95% upper CL
Brachyramphus  NA   NA   NA NA NA      NA      NA
Kittlitz's     12095.63 2198.04 4831399 NA 47.98     8495.73 17220.90
Marbled        59564.83 7732.51 59791783 NA 46.18    46232.88 76741.24
Unknown        NA   NA   NA NA NA      NA      NA

> |

```

Figure SOP 12.3. Estimated population estimates for analyses of population status and trend displayed in the R GUI console. Estimates for *Brachyramphus* and unidentified murrelets are only presented for encounter rates, because other estimates are adjusted to account for unidentified murrelets.

Table SOP 12.1. Data fields for "Encounter_Rates_yyyy.csv" (where yyyy is the survey year). Encounter rates and TRANSECT_KM may vary by survey, but other fields should be invariant unless the survey design changes.

Field name	Type	Description
TRANSECT_ID	string(3) ^a	Transect ID# (3-digit numeric code)
TRANSECT_KM	numeric	Length of surveyed transect in km
ERK	numeric	Encounter rate ^b for KIMU (groups on water/transect length in km)
ERM	numeric	Encounter rate ^b for MAMU
ERU	numeric	Encounter rate ^b for UNMU (unidentified <i>Brachyramphus</i> murrelets)
ERB	numeric	Encounter rate ^b for BRMU (all <i>Brachyramphus</i> murrelets), sum of above 3
LAT_MID	numeric	Coordinate value for latitude of mid-point of transect in decimal degrees
LON_MID	numeric	Coordinate value for longitude of mid-point of transect in decimal degrees
P_INCLUD	numeric	Probability of inclusion of transect derived from sampling design

^aNumber in parenthesis indicates string length.

^bGroups encountered on water within right-truncation distance divided by transect length in km. The right-truncation distance is determined during estimation of the detection function (see SOP 11).

Table SOP 12.2. Data fields for "DISTANCE_Output_yyyy.csv" (where yyyy is the survey year). The after-hyphen suffixes denote the standard error (SE) and degrees of freedom (DF) for estimates. For group size estimates (starting with 'S'), the second character denotes species class ('K' = Kittlitz's murrelet, 'M' = marbled murrelet, and 'U' = unidentified *Brachyramphus* murrelet) and the third character indicates whether estimates are appropriate for population trend (T) or population status (S) analyses.

Field name	Type	Description
Pa	numeric	Probability of detection across transect width P_a
Pa_SE	numeric	SE for P_a
Pa_DF	numeric	Degrees of freedom (<i>df</i>) for P_a
Pc	numeric	Probability of detection near transect center line P_c
Pc_SE	numeric	SE for P_c
Pc_DF	numeric	<i>df</i> for P_c
W	integer	Transect width (meters) w
SKT	numeric	Average group size for KIMU for trend analyses S_{KT}
SKT_SE	numeric	SE of S_{KT}
SKT_DF	numeric	<i>df</i> of S_{KT}
SMT	numeric	Average group size for MAMU for trend analyses S_{MT}
SMT_SE	numeric	SE of S_{MT}
SMT_DF	numeric	<i>df</i> of S_{MT}
SUT	numeric	Average group size for UNMU (unidentified) for trend analyses S_{UT}
SUT_SE	numeric	SE of S_{UT}
SUT_DF	numeric	<i>df</i> of S_{UT}
SKS	numeric	Average group size for KIMU for status analyses S_{KS}
SKS_SE	numeric	SE of S_{KS}
SKS_DF	numeric	<i>df</i> of S_{KS}
SMS	numeric	Average group size for MAMU for status analyses S_{MS}
SMS_SE	numeric	SE of S_{MS}
SMS_DF	numeric	<i>df</i> of S_{MS}
SUS	numeric	Average group size for UNMU (unidentified) for status analyses S_{US}
SUS_SE	numeric	SE of S_{US}
SUS_DF	numeric	<i>df</i> of S_{US}

Table SOP 12.3. Data fields for the text file "R_Output_YYYY.csv" (where YYYY is the survey year).

Field name	Type	Permissible Values	Description
SURVEY_YEAR	integer	≥2010	4-digit survey year
ANALYSIS_CODE	string	TREND	Estimate for population trend analyses
		STATUS	Estimate for population status analyses
ATTRIBUTE_CODE	string	Encounter.Rate	Groups/km
		Adjusted.Encounter.Rate	Encounter rate accounting for unidentified murrelets
		Density	Density (individuals/km ²)
		Abundance	Abundance (within specified survey area)
SPECIES_CODE	string	Brachyramphus	All <i>Brachyramphus</i> murrelets
		Kittlitz's	Kittlitz's murrelet
		Marbled	marbled murrelet
		Unknown	Unidentified <i>Brachyramphus</i> murrelet
ESTIMATE	numeric	≥0	Estimate for specified attribute and species
SE	numeric	≥0	Standard error of estimate
VAR	numeric	≥0	Variance of estimate
N	numeric	≥0	Sample size ^a
DF	numeric	≥0	Degrees of freedom (<i>df</i>) or approximated <i>df</i> ^b
CL_LOWER_95_PCT ^b	numeric	real number	Lower 95% confidence limit
CL_UPPER_95_PCT ^b	numeric	≥0	Upper 95% confidence limit

^aFor estimates combining data with differing sample sizes, sample size is absent and degrees of freedom are approximated. See Appendix A, section A.3.3.

^bField name will reflect user-specified confidence interval coverage.

SOP 13: Managing the Production Environment

Version 1.0

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
	November 2012	S. Hoekman, W. Johnson, B. Moynahan, C. Sergeant	Initial version		1.0

1.0 Summary

In order for most SEAN deliverables to be disseminated to the public, they must be installed in the NPS production environment at the Natural Resource Stewardship and Science Directorate (NRSS) in Fort Collins, Colorado. Certain deliverables must also be installed in production repositories, such as the NPS IRMA Data Store. In order for production content to be generated, various steps must be performed in SEAN's staging environment. Once content is built and verified in the staging environment, it is copied to production for permanent storage and publicly-accessible dissemination.

Many of the detailed SOPs in this protocol end with a reference to propagating the final deliverable into production. This is an implicit reference to this SOP. Not all deliverables are handled in the exact same manner, so methods for installing them into production vary.

2.0 Schematic of the Environments

Figure SOP 13.1 illustrates the major components in the SEAN staging and NRSS production environments. References are also made to SEAN's development and test environments. Details of their operation are not germane to moving deliverables from staging to production and will not be discussed here. Managing those two environments is explained in SEAN Data Management Plan SOP 303 – Organization of Development, Test/Integration, and Production (Johnson and Moynahan 2008).

3.0 Components of the Environments

Major components of the staging environment include the Staging Directory, the Data Management Web Server, the Staging Database, and the Integration Auxiliary Repository. The Staging Directory is a folder on SEAN's local file server used to collect submitted productions and feed them into validation and certification processes. The Data Management Web Server is an internal-only web site holding applications used to validate some deliverables, create certain deliverables, report information used as the basis for other deliverables, and actively track the status of all deliverables in process. The Staging Database is a SQL database used to hold the final KM_E product as well as the deliverable status tables. The Integration Auxiliary Repository is a set of folders and files housed on the local SEAN file server. It contains all certified deliverables except for KM_E, which can only exist on a database server.

The production environment consists of the Production Database, the Replica Auxiliary Repository, and the Production Web Server. The Production Database houses all final KM_E data. The Replica Auxiliary

Repository is a mirror of the Integration Auxiliary Repository. The Production Web Server houses the public dissemination point. It draws content from the other two components.

Two additional production environments, which receive copies of certain items from the Integration Auxiliary Repository, are the NPS IRMA Data Store and Alaska Resources and Information Services (ARLIS). Delivering content to these repositories is SEAN's only role and responsibility in the management of these external repositories.

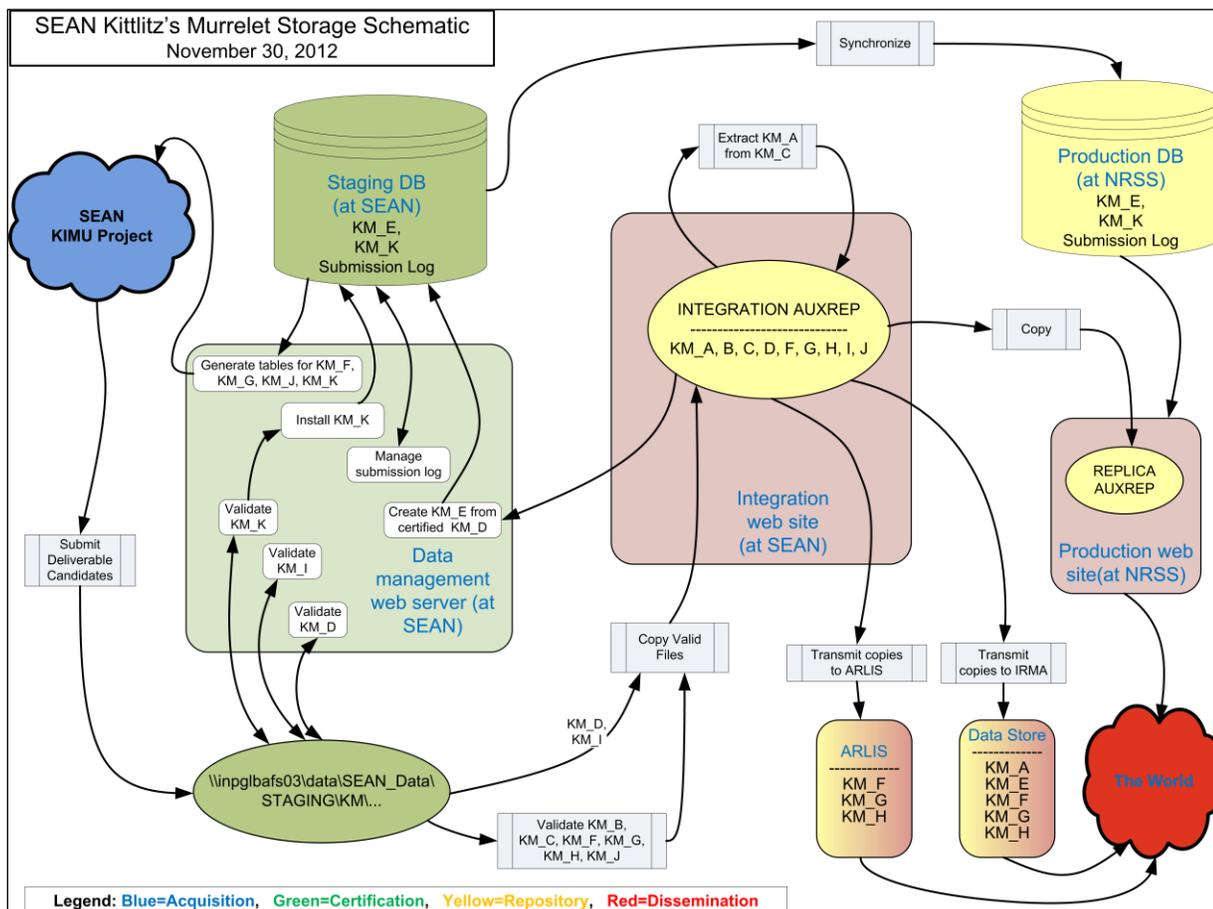


Figure SOP 13.1. Components of the staging and production environments. Coloring indicates the functional realm of each component, as defined in the SEAN data management plan. Rectangles depict the data management tasks required to move a product from one component to the next. Internal functions provided by the data management web server related to KIMU are also listed.

4.0 Data Management Processes

Figure SOP 13.1 shows as rectangles the specific tasks needed to move a deliverable from the submission-to-staging through the production-dissemination states. These are primarily data copying steps achieved either by file transfer or by SQL database synchronization. No attempt will be made to detail specific commands and information technology processes to accomplish these particular tasks. They are dependent on the current complement of equipment components, software versions, security policies, and NRSS operating procedures. Most of the tasks are performed only once per year. The data management staff is expected to determine the best method to use at each particular invocation. These specific tasks fit in the general management framework, operation of which is detailed in the data management plan's SOP 303 (Johnson

and Moynahan 2008). Understanding framework operation is a prerequisite to performing the KM protocol-specific processes.

The data management web site supports a number of necessary tasks required in accomplishing the staging to production process. These are depicted in Figure SOP 13.1 as rounded rectangles within the data management web server object. Their use is explained in the various SOPs covering detailed creation of data deliverables.

Literature Cited

Johnson, W. F., and B. J. Moynahan. 2008. Data management plan: Southeast Alaska network. Natural Resource Report NPS/SEAN/NRR—2008/058. National Park Service, Fort Collins, Colorado, USA.

SOP 14: Transect Redefinition (KM-A Update)

Version 1.0

Revision History Log:

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

Purpose

The survey designer defined this program’s original transects. Over the course of three field seasons (so as to include all panels), actual boat tracks were recorded. These did not exactly coincide with the originals due to presence of physical obstructions as well as slight inaccuracies in the original GIS shoreline features. The KM-A product group was redefined to match these ground-truthed locations and is now expected to be immutable. However, if additional changes in exact transect locations are required in the future, the following tasks should be performed to fully and consistently incorporate them into the program.

SOP 2 requires users to work with GIS and database tools in the internal NPS network under valid Active Directory accounts. Access questions should be directed to the Data Manager.

1. Use Windows explorer to make a copy of the directory containing the certified file geodatabase and MXD file to perform the edits on.
2. Use ArcMap to revise items in the TRANSECT feature.
 - a. Visually hand edit the endpoints – typically to match accurate “on transect” TRACK_LOG items generated during field work.
 - b. Use the “calculate geometry” function to revise the four endpoint columns in the TRANSECT table (i.e., two latitude-longitude pairs).
 - c. Export TRANSECT feature for eventual inclusion into the website KM_A deliverable. (There are typically seven files generated for the feature.)
3. Use ArcMap to revise corresponding items in the TRANSECT_SCOPE feature.
 - a. For a mid-water terminating transect, draw the TRANSECT_SCOPE endpoint to correspond to the same location as TRANSECT.
 - b. For transects terminating shoreward, draw TRANSECT_SCOPE endpoints at the shorter of either the actual shoreline or 150m. That is, the scope endpoint is to extend no more than 150m beyond the boat endpoint.
 - c. Use the “calculate geometry” function to revise the two midpoint coordinate columns in the TRANSECT_SCOPE table.
 - d. Export TRANSECT_SCOPE feature for inclusion in the website KM_A deliverable. (There are typically seven files generated for the feature.)

4. Use ArcMap to create a visual map of transects.
 - a. Display only the boat TRANSECT feature – not TRANSECT_SCOPE.
 - b. Be certain transect ID numbers are properly labeled on all transects – the label engine has historically had problems with this.
 - c. Mark the revision date on the legend.
 - d. Export the map to a JPEG file with resolution of 200x200 DPI for inclusion in the website KM_A deliverable.
5. Use ArcMap to create a new spreadsheet of boat transect endpoints for GPS uploading.
 - a. Note this is required to generate multi-point routes for zigzag transects.
 - b. Create a new TRANSECT_SEGMENTS feature using the Features/Split Line at Vertices tool with an input feature of TRANSECTS.
 - c. Use the “calculate geometry” function to revise the four endpoint coordinate columns in the TRANSECT_SEGMENTS table.
 - d. Add a new field to TRANSECT_SEGMENTS called “unique_id” and use the field calculator to generate this as <Transect_ID & “.” & Object_ID>.
 - e. Export the feature to a DBF.
 - f. Open the DBF in Excel, sort it by unique_id, clean up the headings, and hide any fields not relevant to defining the GPS track.
 - g. Print this sheet out, laminate it, and include it in the data management box for use in the next field season.
 - h. Be sure the revised table gets reflected in the boat GPS used for navigation.
6. Use ArcMap to create a new spreadsheet of transect scope definitions for loading into the SQL database.
 - a. Use a database tool to review the attributes required to be in tbl_km_transect_scope.
 - b. Copy the TRANSECT_SCOPE feature into a new one as the basis for the SQL table.
 - c. Add constant columns (protocol_id, userid, etc.) to the basis. Fill them using the field calculator.
 - d. Join the TRANSECT table to it.
 - e. Turn off extraneous fields.
 - f. Export the feature to a DBF file.
 - g. Use Excel to edit the DBF with column headings that match the database table names and rearrange the table order to match the database order.
 - h. Retain the DBF for updating the SQL database in a subsequent step.
7. Use VisualStudio to update the development website.
 - a. KM_MAIN.ASPX should have its text revised to reflect the new KM_A revision date.
 - b. Zip the exported feature files for TRANSECT and TRANSECT_SCOPE into a single file called KM_A_shapefiles and copy it to the website's AuxRep\KM\KM_A directory.
 - c. Copy the new visual map file to AuxRep\KM\KM_A\KM_A_image.jpg.
 - d. Verify the development website reflects the new KM_A components.
8. Propagate the development website through staging to production as outlined in SOP 13.
9. Use a tool such as SQL Server Management Studio or SQL Maestro to replace tbl_km_transect_scope in the Integration database.
 - a. Create a safekeeping copy of the original table and name it tbl_km_transect_scope_obsolete.

- b. Replace all rows in the existing tbl_km_transect_scope with the contents of the SQL_Table spreadsheet created earlier.
 - c. Verify the development website reflects the new values when doing the "Download Transect Table" function.
 - d. Propagate the Integration database change to the Production database and verify the Production website reflects the revised transect table.
10. Because this deliverable is expected to be immutable, additional formal data validation and certification tasks are not expected to be required.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 953/122865, November 2013

National Park Service
U.S. Department of the Interior



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