EVALUATING METHODS TO CENSUS BREEDING ALEUTIAN TERNS AT A COLONY IN YAKUTAT, ALASKA

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Summary

We evaluated three different transect-based survey techniques and one remote sensing technique to census Aleutian Terns (*Onychoprion aleutica*) at a breeding colony on Black Sand Spit near Yakutat, Alaska. We took vertical low attitude aerial photos of the colony. Terns were counted from aerial images manually and using automated software. Two observer-teams walked a transect through the colony. Observers recorded perpendicular distance from the transect to each chick, nest scrape, egg shell, and occupied nest (nest with eggs) detected. Population estimates were generated from the transect post hoc using the strip transect method, the variable-area transect method (VAT) and distance sampling (program DISTANCE). Aerial photo interpretation was unsatisfactory because, although terns were clearly detectable, many features could not be positively accepted as terns. Automated interpretation of imagery yielded too many false positives resembling terns in size and spectral characteristics to be of further utility. Among the 3 ground survey techniques, distance sampling provided the most robust population estimate (coefficient of variation of 12.9), whereas VAT and strip transects yielded highly variable estimates. In mixed colonies where species composition ratios are also known, distance sampling for occupied nests can be applied as an inexpensive, statistically valid, and repeatable method to monitor tern populations at colony sites.

Introduction

The Aleutian tern (*Onychoprion aleutica*) is a migratory seabird that exemplifies both the challenges faced by modern researchers censusing wildlife populations, and the importance of population estimates to the conservation of the species. Despite having been described over 150 years ago, almost nothing is known about the Aleutian tern outside of the brief period when it appears at coastal breeding colonies. It is cryptic, rare and thought to be highly migratory.

The global population of approximately 32,000 Aleutian terns is believed to breed exclusively in Alaska and eastern Siberia (North 1997). A significant portion of the 9000-12000 Alaskan population forms large (> 100 individuals) mixed breeding colonies with Arctic Terns (*Sterna paradisaea*) (North 1997 USFWS 2003). Although there are no long term data sets of accurate population sizes, anecdotal evidence is consistent with the possibility that colony sizes have undergone slight to severe declines in Southcentral and Southeast Alaska

The requisite first step in evaluating population trends is developing a robust methodology to survey Aleutian Terns at large mixed colonies. Large Aleutian Arctic tern colonies pose several challenges to enumeration. These challenges include: (1) Detection error. Arctic and Aleutian terns are morphologically similar and even experienced observers can't differentiate the species at greater distances (Kaufman 1990). (2) Observer Bias. The tolerance of Aleutian terns to human observers at colonies is unknown but several sources report that Aleutian terns can be moderately sensitive to disturbance (Buckley and Buckley 1979; North 1997). Therefore, survey methods and parameters that minimize the time observers spend in the colony are critical. (3) Counting Bias. Terns are also highly dispersive at the nest site, so designing effective ground-based counting procedures need to be considered.

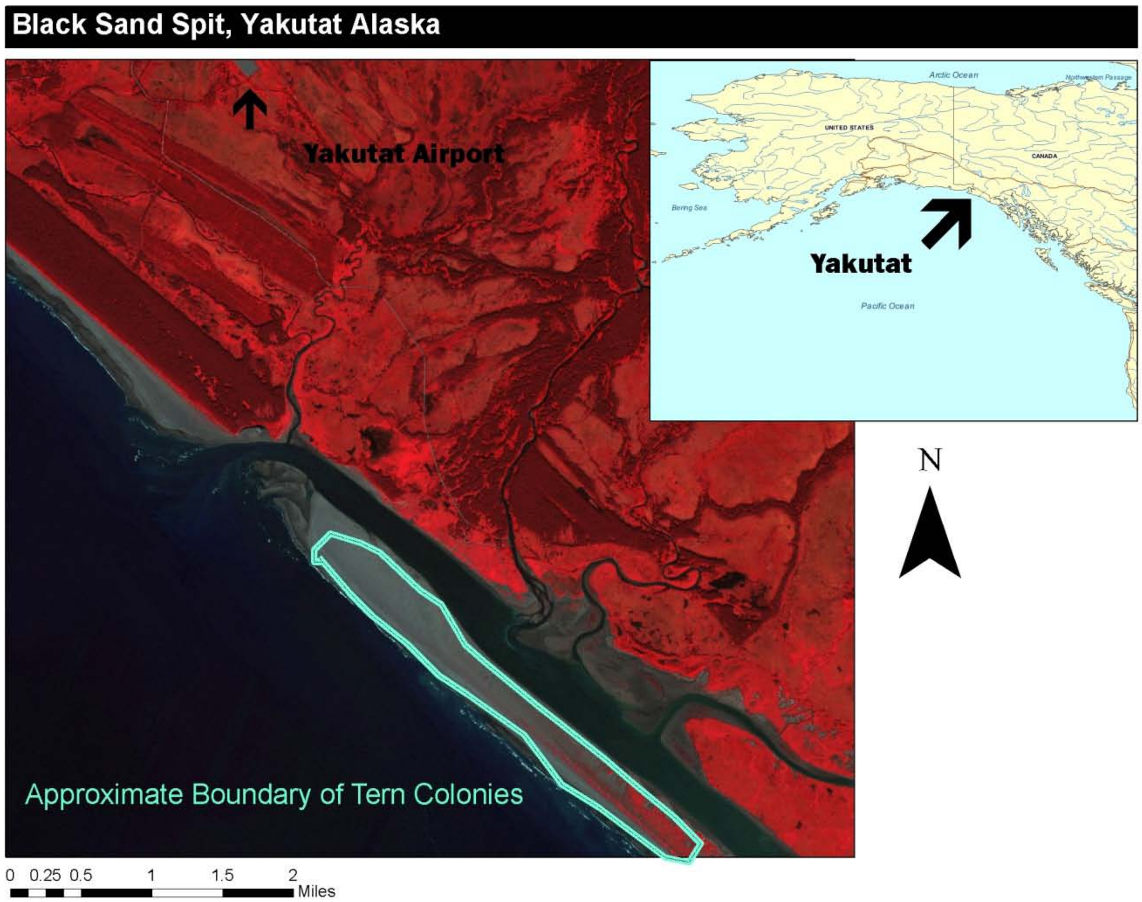
These concerns prompted several commonly used census techniques to be eliminated from the project during the planning phase. Arctic and Aleutian tern nests are small and dispersed. Quadrate surveys for nests or other evidence of breeding terns, would require observers to spend a prolonged period of intensive searching within the boundaries of the colony. This is problematic since Sutherland (2006) recommends that a survey methodology for colonial seabirds should flush birds from their nest for period of less than 30 minutes. Unless blinds were used, point counts of nesting adult terns would have also have a significant disturbance effect. However, blinds require construction, maintenance and are ill suited to these large dispersed colonies whose boundaries may fluctuate annually. Flush counts are well suited to small tern colonies but not to colonies of greater than 200 pairs (Southernland 2006, Bibley et al 2007). When flushed, Aleutian and Arctic terns circle and intermingle over the colony making ocular estimates of large numbers of birds impractical. At large colonies flush counts are further complicated by an unknown and variable number of non breeding individuals that may be present on the colony.

Transect surveys which estimate density without fixed plots, and direct counts from aerial photography were selected as the most promising methods to apply to large mixed colonies. The objective was to evaluate these techniques at a large mixed Aleutian and Arctic tern colony in order to develop a standardized statistically sound survey technique that could be applied and repeated at known important large Aleutian tern colonies.

Methods

Study Site

Black Sand Spit is a narrow barrier beach which forms the boundary between the Situk River Estuary and the Gulf of Alaska. Arctic and Aleutian terns nest in a mixed colony at the northwestern edge of the spit. An early documented observation indicates that Aleutian terns have been breeding on Black Sand Spit since at least 1916 (Walker 1923). Estimates have been as high as 3000 Aleutian terns in some years making Black Sand Spit among the largest documented colonies in the world (Oehlers 2007). In contrast to most documented Aleutian Tern colonies Black Sand Spit is relatively accessible. Activity from a nearby commercial fishery may make the colony more tolerant of human disturbance then other sites



Aerial Photo Methodology

We modified a Cessna 185 aircraft and fitted it with a custom designed camera mount. We flew three survey flights over the Black Sand Spit Colony during the 2008 breeding season. We took photos at different combinations of altitude, focal length, and air speed using 6 and 13 megapixel digital SLR cameras.

Survey photos were downloaded and post processed using Adobe Photoshop software. A photo mosaic of the Black Sand Spit colony was generated and geo-referenced using ArcGIS. We attempted to estimate the number of birds in the photos using 2 techniques: (1) we systematically searched for nesting birds using a grid superimposed on the image; and (2) used the Feature Analyst extension of a GIS program to perform automated counts of birds (fig 1).

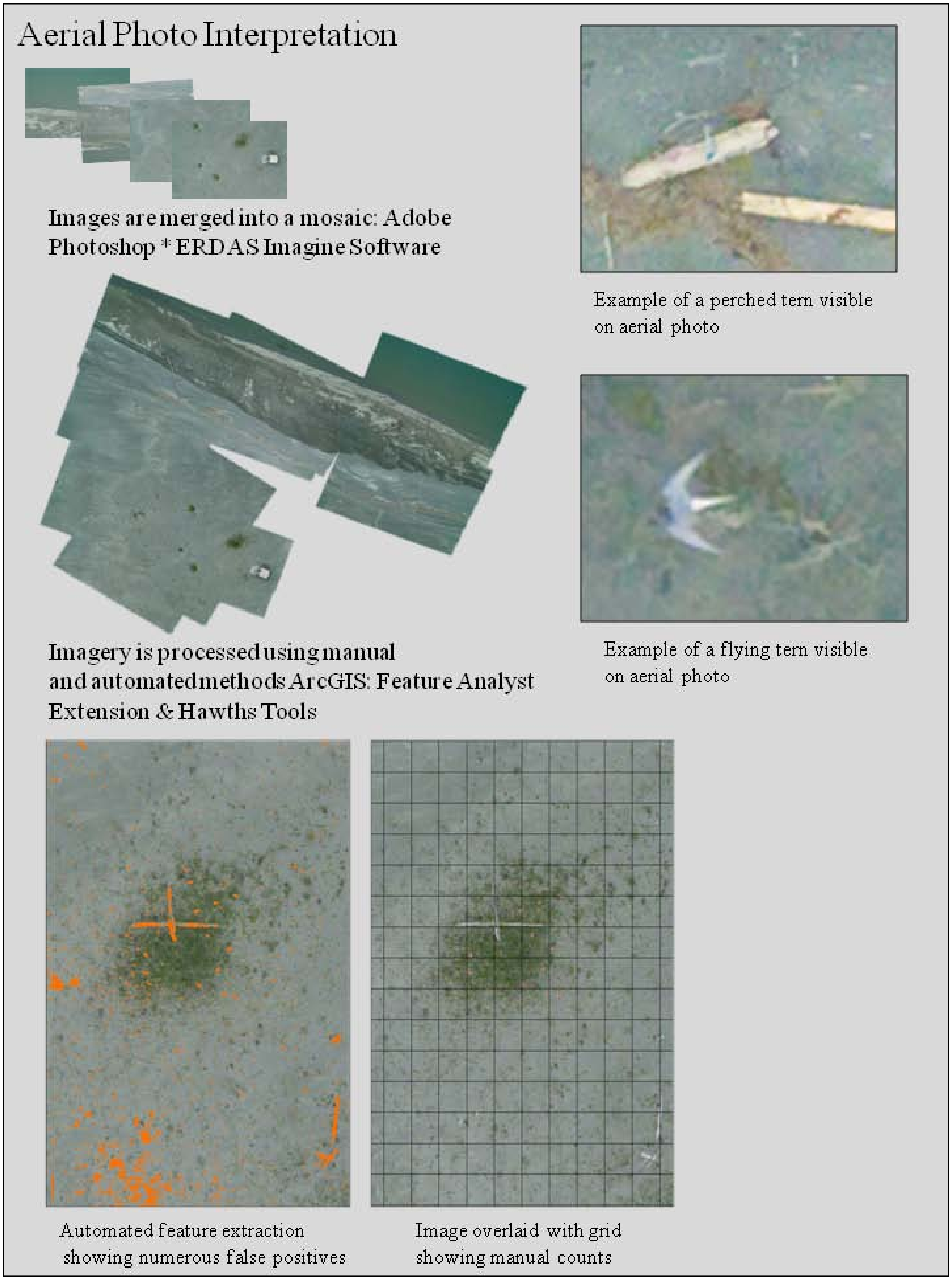


Fig 1. Aerial photo methodology and analysis.

Ground Based Survey Methodology

We designed a single-pass transect methodology that encompassed a combination of the variable area transect (VAT), strip transect and distance-sampling (Program DISTANCE) survey techniques. Two observer-teams walked a transect through the colony during the breeding season. Several static features were available at the colony that were counted to evaluate as indicators of breeding terns. Observers teams recorded distance from the start of the transect and perpendicular distance from the transect, to each chick, nest scrape, egg shell, and occupied nest (nest with eggs) detected during the survey. We implemented the survey three times at roughly a 10 day interval during the breeding season to capture changes in phrenology at the Black Sand Spit tern colony.

Strip transect method

$$\widehat{D} = \frac{n}{wL}$$

The strip transect method is used frequently in ecological studies to estimate the number of species in a given area or species density (*D)*. In this method observers search a transect of a fixed length (*L*) and width (*w)* and record all the features (species, or evidence of a species) found during the survey. In this methodology density is calculated by dividing the number of features found, by the total area searched (*wL*).

By sorting the data by perpendicular distance from the transect and distance from start of the transect, we modeled the density estimates that would be generated by transects of different lengths and widths. We modeled transects at widths of 45cm, 2 meters, and 5 meters. As recommended by Dobrowski, and Murphy (2006) a 45cm represented the twice the width of the average nest scrape, or a transect in which only features that fall directly on the transect line. A 2 meter wide transect is recommended by Sutherland (2006) for use in seabird colonies. A five meter transect was selected post hoc based on the threshold level recommended by the observers. We modeled transect at lengths of 100 meters, 500 meters, and 1000 meters. To examine relative variation we generated density estimates for each combination of variables starting at 40 random points along the transect and calculated coefficient of variation for each sample.

Variable Area Transect

$$\widehat{D} = r / \left(w \sum x_i \right)$$

In contrast to strip transects, the variable area transect method is used to estimate density by calculating the area per species. In this method observers search a fixed width (*w*) transect till they encounter a predefined (*r*th) number of features. The length of the transect searched (*x*i) is recorded and divided by the *r* number of organisms.

We modeled transects at widths of 45cm, 2 meters, and 5 meters and at *r* = three, four, and five. To examine relative variation we generated density estimates for each combination of variables starting at 40 random points along the transect and calculated coefficient of variation for each sample.

Distance Sampling

In Distance sampling, observers do not search a transect of a fixed width but instead record every species or feature detected from the transect center line. When detected, each species or feature is recorded along with the perpendicular distance from the transect center line from which it falls. The data is analyzed in Program Distance which assigns a detection function to the relative number of features detected at different distances from the line to produce a scaled density estimate (Buckland et. Al 2001).

Results

Aerial Photo Interpretation

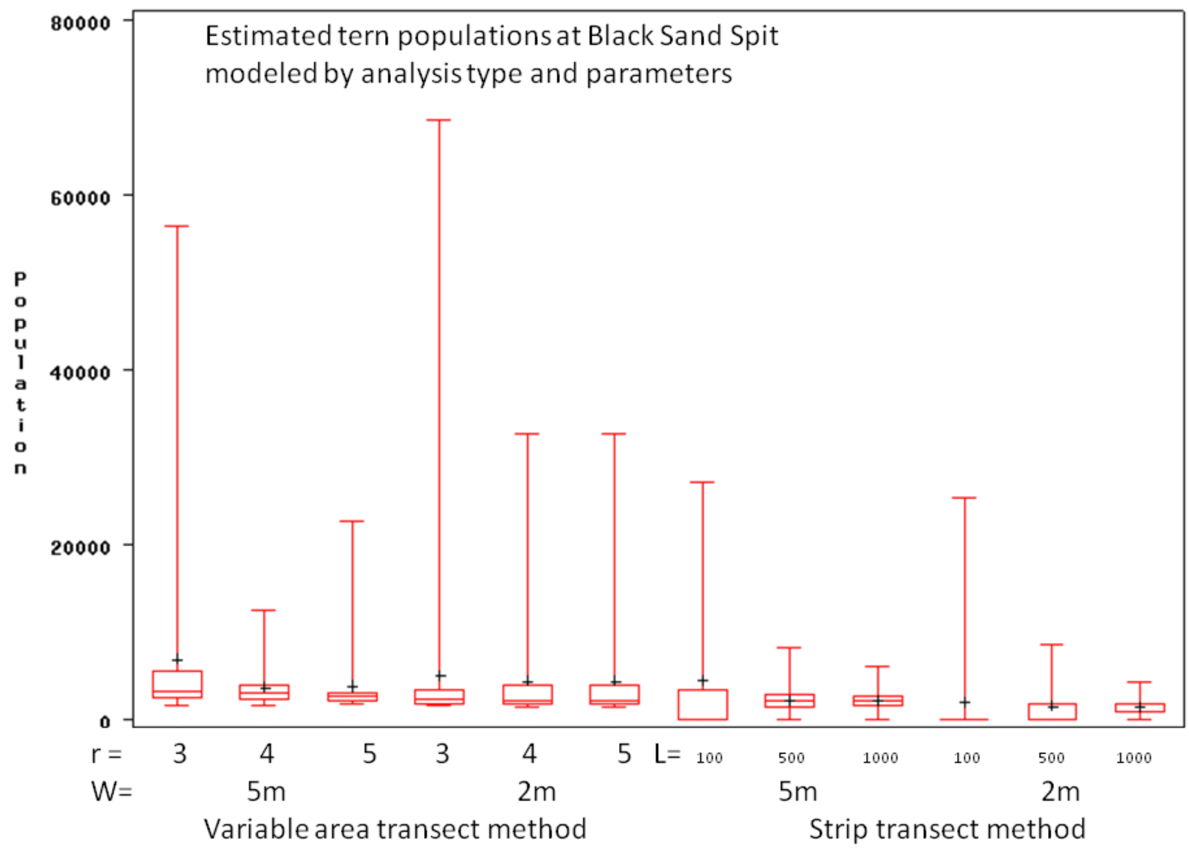
Terns were only detectable on survey photos taken with the 13 megapixel camera at the highest focal length (135mm) and flown at the lowest altitude (500ft) tested. While some breeding terns were clearly visible on survey photos taken under these conditions, neither counting technique provided satisfactory results. The manual technique grossly underestimates nesting occurrence. Counts were very low, even in situations when known objects were placed on the ground. The automated technique grossly overestimates counts because other features (e.g. tree limbs, substrate, etc) on Black Sand Spit resemble terns in size and or spectral characteristics (fig 1).

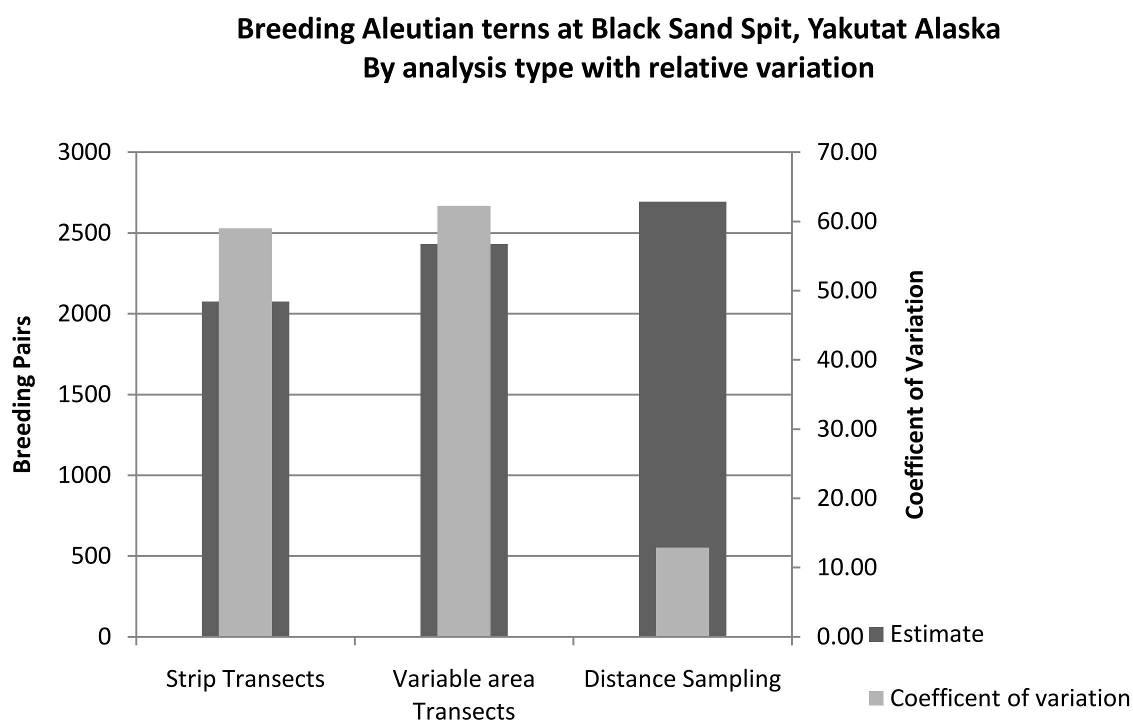
Ground Based Results

The peak transect survey occurred on June 29 2008. The survey consisted of a single 3.39 kilometer transect across the 418 acre colony. During the survey 255 features were recorded including 65 occupied nests. Due to significant differences in observer detection, nest scrapes and shells were eliminated from the analysis. Chicks were eliminated from the analysis because they were rarely detected by observers (peak chick count of 12 amongst the three surveys).

Population estimates for the colony were generated by extrapolating occupied nest density along the transect to the whole colony area (418 acres) and then applying a species ratio for the colony identified during a separate survey. Each nest was equated with two breeding terns (Southerland 2007).

Variable area and strips transects were likely to produce highly variable estimates (fig2). Coefficient of variation for the samples of strip and variable area transect models ranged from (59 to 256). As expected variation declined in strip transects of a greater length and width and variable area transects searched to a higher *r* but these estimates were significantly less variable then those produced using distance sampling (coefficient of variation of 12.9).


Estimated tern populations at Black Sand Spit
modeled by analysis type and parameters
80000
60000
40000
20000
0
Population
r = 3 4 5 3 4 5 L= 100 500 1000 100 500 1000
W= 5m 2m 5m 2m
Variable area transect method
Strip transect method


Breeding Aleutian terns at Black Sand Spit, Yakutat Alaska
By analysis type with relative variation
3000
2500
2000
1500
1000
500
0
Breeding Pairs
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Coefficent of Variation
Strip Transects
Variable area Transects
Distance Sampling
Estimate
Coefficent of variation

Discussion

Transect based distance sampling for occupied nests, represents a statistically valid, and repeatable method that can be applied to large mixed Aleutian tern colonies. Distance sampling and enumerating occupied nests are well recognized as robust components of many ecological census studies (Bibley et al 2007, Southernland 2006, Buckland et al 2001). Distance sampling accounts for inherent detection error at greater distances from the transect line. As a result observers are not constrained to a transect of a specific width and data collection is more efficient. For example, modeling a fixed transect with a width of five meters still reduced the pool of occupied nests available for analysis by just under 50 percent.

This methodology also is well matched to conditions in the field and the specific challenges posed by these colonies. Observers are able to move relatively rapidly along the transect and the survey does not extend the period in which birds are flushed from the nest beyond the thirty minute threshold. Focusing on occupied nests eliminates bias associated with large flocks of birds and non breeders. Finally, observers without a great amount of familiarity with terns nests maybe able to collect a few additional nest site measurements that can be used to differentiate the two species of tern nests (See Appendix I).

Although aerial photography was not successful in this application it should not be completely dismissed as a technique in future survey projects. Interpretation was marginal with a 13 megapixel camera but might improve with the higher resolution equipment. Digital cameras are increasingly available at higher resolutions and 21 megapixel digital SLR cameras are currently available on the market. Large format mapping cameras designed for aerial photography should also be evaluated. However, achieving high resolution complete coverage of large dispersed tern colonies is expensive and requires a skilled pilot. A large amount of post processing is associated with each survey. Viewed from above, Aleutian terns can be difficult to differentiate from their surroundings. This crypsis is likely an adaptation to avoid detection by aerial predators. Even aerial photography that achieves sufficient resolution to identify all terns would still require an additional large amount of interpretation time to enumerate Aleutian terns.

Literature Cited:

Baird, P.A.1986. Arctic and Aleutan Terns. Pp. 349-380 *in* The breeding biology and feeding ecology of marine birds in the Gulf of Alaska. Environmental Assessment of the Alaska Continental Shelf, Vol. 45.

Bibby, C. J. Burgress, N. D. Hill, D. A. Mustoe, S. H. 2000. Bird Census Techniques
San Diego CA: Elseiver ltd.

Buckley, F.G., and P.A. Buckley. 1979. Do Aleutian terns exhibit extraordinary anti-predator adaptations? Proc. Colonial Waterbird Group Vol. 3:99-107

Buckland, S. T. A., D.R. Burnham, K.P. Laake, J.L. Borchers, D. L. Thomas, L. 2001. Introduction to Distance Sampling. New York, NY: Oxford University Press

Dobrowski, S. Z. and S. K. Murphy (2006). "A PRACTICAL LOOK AT THE VARIABLE AREA TRANSECT." Ecology **87**(7): 1856-1860.

Kaufman, K. 1990. A field guide to advanced birding. Petersen Field Guide Series
New York, NY : Houghton Mifflin Company

Moran, M. 2005. *Unpublished Report*. West Forelands Landscape Assessment Chapter 5 Synthesis and Recommendations. USDA Forest Service

North, M.R. 1997. Aleutian Tern (*Sterna aleutica*). In The Birds of North America, No. 291 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and the American Ornithologists' Union, Washington, D.C.

Oehlers, S. 2007. *Unpublished Report*. Aleutian and Artic Tern Analysis Supplement to the to ATM Wildlife Specialist Report. USDA Forest Service Yakutat Ranger District

Sutherland, W. L. (2006). Ecological Census Techniques. New York,NY, Cambridge University Press.

Stenhouse, I.J., and S.E. Senner. 2005. Alaska Watch List-2005. Audubon Alaska, Anchorage AK.

U.S. Fish and Wildlife Service, 2006a. Beringian Seabird Colony Catalog -- computer database and Colony Status Record archives. U.S. Fish and Wildlife Service, Migratory Bird Management, Anchorage, Alaska.

U.S. Fish and Wildlife Service. 2006b. Alaska seabird information series: Aleutian tern. http://alaska.fws.gov/mbsp/mbm/seabirds/pdf/alte.pdf

Walker, E. P. (1923). "Definite Breeding Record for the Aleutian Tern in Southern Alaska." The Condor **25**(4): 113-117.

Appendix I

Arctic and Aleutian Tern Breeding Colony Survey Protocol

Introduction

Aleutian terns (ALTE) are a colonial seabird of Alaska and Siberia. In Alaska, Aleutian tern colonies occur in a variety of sizes and habitats. ALTE also nest with Arctic terns (ARTE). The following nest-based transect protocol can be used to census ALTE and ARTE at breeding colonies. Do not implement the protocol during periods of heavy rain or other inclement weather when colony disturbance could endanger eggs and chicks. Colony entry and the transect can be completed rapidly with simple equipment. The methodology consists of distance sampling along a transect and four fine scale measurements taken at each nest. The transect generates a density estimate for breeding terns and the nest measurements allow for differentiation between species.

◀Tern nest on Black Sand Spit nears Yakutat AK

▲Observers measure perpendicular distance from the nest to the transect line

Survey Protocol Outline

1. Identify a colony
2. Delineate the colony
3. Identify a transect
4. Initiate the transect

4a. Take 2 distance measurements and 4 nest measurements for each nest detected

4b. Repeat until transect is completed

Identifying a colony

ALTE select lightly vegetated areas on beaches, spits, and salt marshes to breed. ARTE tern colonies should be evaluated for ALTE presence. Multiple con specifics landing on the ground, nests, shell fragments and scrapes are all good indicators of a breeding colony. Terns, especially ARTE, are defensive of their breeding colonies and will call loudly and dive bomb intruders. ALTE are less likely to aggressively harass intruders. Instead, Aleutian terns will flush and hover above the colony alarm calling.

Delineating the colony and selecting the transect

Tern colonies present fewer challenges to delineation then many habitats. They are generally located in open areas adjacent to water with obvious breaks in the vegetation type. On a spit for instance, three sides of the colony is surrounded by water. On a beach the colony would not penetrate the forest. It is best to be generous and use natural boundaries to capture an area that contains the entire colony. A lower density for a larger area is preferable to an area value that doesn't capture the whole colony. Use a GPS to take waypoints and sketch the boundaries in a field book or on a recent aerial photo.

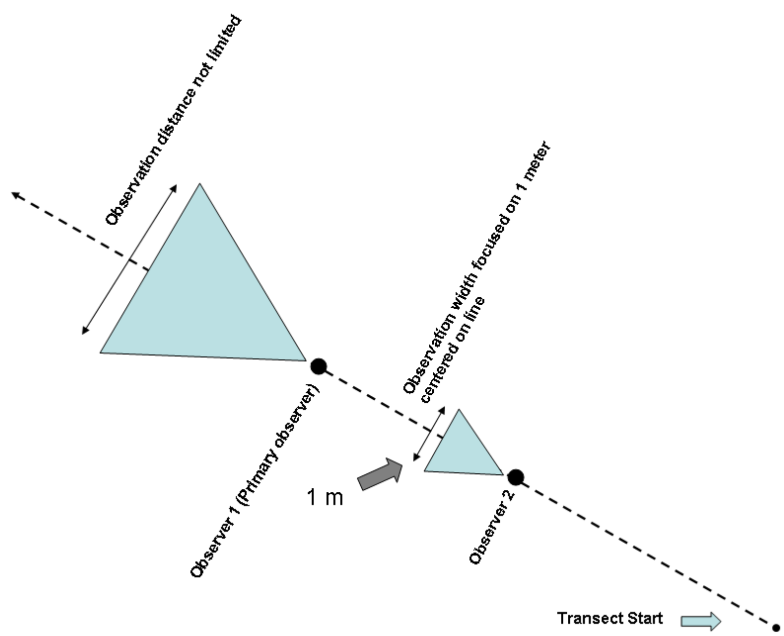
Select a straight line transect that maximizes the area searched in a single pass through the colony. Do not attempt to target areas with the highest density of nesting birds. Determine the bearing of the transect line.

Transect Methodology

Nests can be defined as a **scrape containing tern eggs** and or a newly hatched chick. Tern nests consist of little more than shallow excavations in the ground called scrapes however, terns excavate scrapes which aren't used as nests. Scrapes without eggs, shells, and abandoned isolated eggs are not recorded.

Survey teams consist of two observers following a transect through the colony recording nests. Basic distance sampling methods as described by Buckland et al (2001) are followed. In summary, observers do not search out to a specific width but remain on a transect line and record nests detected from the line (Fig 1). The first observer is the primary observer and maintains the transect bearing. The second observer focuses on the area one meter to either side of the line to ensure that detection error is very low along the line.

Fig 1 Survey Transect

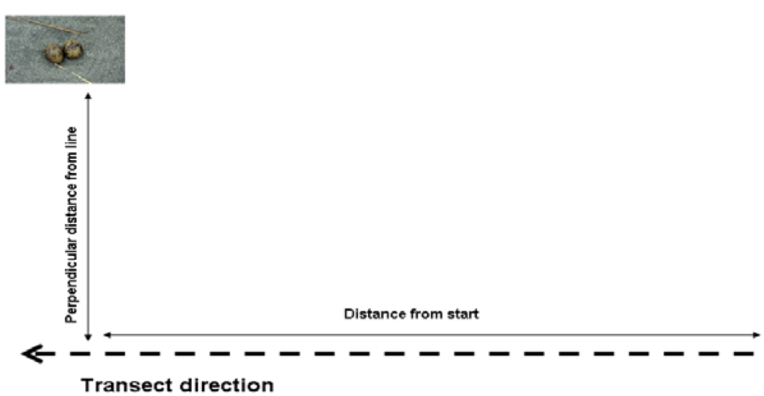


All nests detected **from the line** are recorded on the data sheet. The two distance measurements recorded for each nest are the perpendicular distance to the nest, and the distance from the start of the transect to the point on the line from which the nest was detected (Fig 2). Depending on the size of the colony, distance from the start can be recorded with a survey GPS, (Garmin 76CSX, Trimble), reel tape, or a distance measuring wheel. Perpendicular distance from the transect should be measured with a tape.

Don't record nests detected while taking nest measurements or any nest not detected from the line. All habitat along the survey should be scanned with a relatively equal amount of effort: survey teams should move at a relatively consistent speed. Tailor speed to ensure 100 percent detection along the line. If the first observer is missing nests in the 1 meter range, then decrease your speed. Guard against letting flushing birds or aggressive defensive terns bias the search effort. Record survey start and stop times. A digital camera is handy to photograph unidentified nests and other questionable features.

Survey members should be familiar with tern nests. If you are not familiar with tern nests then a short search of a different part of the colony to develop a search image is a good idea. It is also useful to lay a meter stick alongside the transect to calibrate observation distance for the second observer.

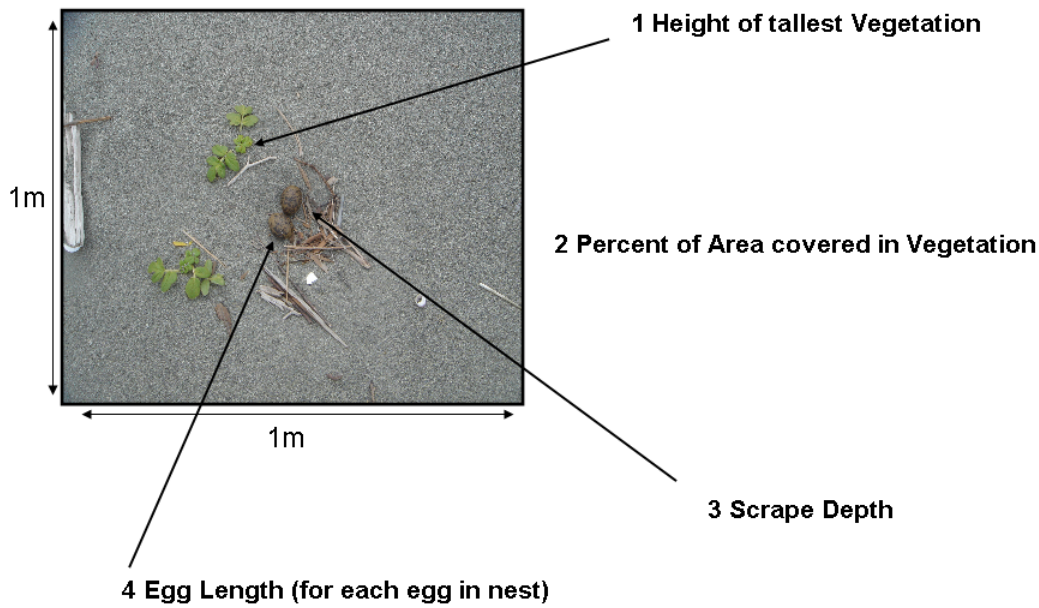
Fig 2 Distance Measurements



Fine Scale Measurements

Four fine scale measurements are taken for each nest detected along the transect (Fig. 3). At the nest observers record egg length and scrape depth. A one meter plot is centered on the nest and height of the tallest vegetation and percent area covered by vegetation within the plot are recorded.

Fig 3 Nest Measurements



Survey Equipment

Item	Use
Binoculars	Determine colony extent
Field Guides	Identification (specifically Bowman 2008)
Watch	Recording start and stop time
Digital Camera	Documenting Unid. Nests
Compass	Following transect
GPS (Garmin 76cx or Trimble)	Marking colony boundaries / Measuring distance from start
Distance measuring wheel	Measuring distance from start
Measuring tape	Measuring distance from start / Measuring perpendicular distance
Calipers	Measuring egg length
PVC 1 meter plot	Delineating habitat plot around nest
Meter Stick	Measuring perpendicular distance / Measuring scrape depth
Rubber Gloves	Handling eggs

Tern Survey Data Form

Colony ID	Transect#	Sky Condition
Date	Start time	Start Lat Lon
Observer 1	End time	End Lat Long
Observer 2		WGS 1984

Nest #	Observer	Perp Dist (cm)	Dist From Start (m)	Height of tallest veg (cm)	% Cover	Scrape depth (cm)	Egg length (mm)	Comments

Additional Comments: Other breeding species, predator sign, disturbance