Sea Duck Joint Venture
Annual Project Summary
FY 2018 – (October 1, 2017 to Sept 30, 2018)

Project Title: Integrating Fixed-Wing and Helicopter Survey Platforms to Improve Detection and Species Identification of North American Breeding Scoters

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Financial support provided by Canadian Wildlife Service and Sea Duck Joint Venture (USFWS)

Project Description

Populations of North American breeding scoters appear to be declining although a large degree of uncertainty remains around estimates of population size and overall trends (Bordage and Savard 1995, Savard et al. 1998, Caithamer et al. 2000) due to observation challenges particular to this group of sea ducks. We propose to conduct experimental fixed-wing and helicopter integrated breeding surveys over portions of the core breeding range, in Québec-Labrador and the Barrenlands of the Northwest Territories, of all three North American scoter species. A secondary objective of the proposed work is to produce habitat selection models which will provide more detailed information on the distribution of breeding scoters across core areas of the breeding range and provide the information required to develop a cost-efficient stratified sampling approach.

We proposed a three-year project to evaluate geographic and annual variation and extent in the following parameters from both fixed-wing and helicopter survey platforms: 1- detection probabilities; 2- species identification /composition; 3- differences in availability bias between the two platforms (i.e. correction factor to apply to the platform with lower detection probability). More specifically, year 1 focused on assessing optimal survey timing from published and unpublished information, developing preliminary habitat models, and determining species composition and helicopter detection probabilities in the core breeding area of the Northwest Territories and Manitoba. In year 2, fixed-wing transects were introduced, which will allow development of the dual-platform integrated survey approach. Helicopter and fixed-wing surveys were carried out at two sites in June 2018: Yellowknife area and Lynx Lake area, both in the Taiga Shield Ecozone of the Northwest Territories. Year 3 (2019) activities will include helicopter and fixed-wing surveys in Eastern Canada, likely at the border of Québec and Labrador, and potentially at one other site in Nunavut to sample different habitats and improve the habitat selection modeling. There will also be activities related to post-survey obligations (e.g. removing fuel containers) and report writing. If additional work is required, a new proposal would be presented to SDJV.

The proposed work will be highly relevant to the WBPHS review by addressing issues of coverage, reallocation of survey effort and survey timing for sea ducks. Priority information needs outlined in the SDJV sea duck harvest assessment report will also be partially addressed, by providing estimates of abundance for the experimental survey areas and ultimately proposing an approach for continental population estimation. The principal outcome of the proposed study will be the production of a recommendation document describing the appropriate methodology, potential costs and feasibility of implementing operational continental breeding ground scoter surveys to SDJV and Federal Wildlife Agencies.

Objectives

The overarching goal of the proposed study is to develop an aerial breeding ground survey methodology for scoters that would be applicable at population or continental scales. We are proposing a survey across the Boreal Region of Canada that would integrate fixed-wing transects and helicopter plots to allow for species identification, assessment of species composition and the estimation of detection probabilities.

There are 6 main objectives for the proposed study:

1. Identify the optimal timing for breeding scoter surveys, based on data from previous nesting and productivity studies
2. Develop and evaluate methodology to accurately assess species identification and composition from an integrated fixed-wing and helicopter survey
3. Develop and evaluate methodology for estimating detection probabilities from an integrated fixed-wing and helicopter survey. This will address the perception bias component in both fixed-wing and

helicopter components as well as availability bias from the fixed-wing component, allowing the estimation of visibility correction factors

4. Evaluate annual and geographic variation in species composition and detection probabilities to determine whether these components would need to be measured annually and/or across the range in an operational survey
5. Derive baseline abundance estimates for the experimental survey areas for all three populations of eastern scoters
6. Develop habitat selection models and test hypotheses about factors influencing scoter distribution across the survey area

The development of aerial survey techniques and protocols to improve estimates of detection probability, population trends and numbers and to better classify scoters to species have been identified as Priority Science Needs by the Sea Duck Joint Venture for FY2017. Populations of North American breeding scoters appear to be declining although a large degree of uncertainty remains around estimates of population size and overall trends (Bordage and Savard 1995, Savard et al. 1998, Caithamer et al. 2000) due to observation challenges particular to this group of sea ducks. This lack of population information severely limits our ability to manage scoter habitat and harvest (Koneff et al. 2016).

Several aspects of their distribution and biology make these species somewhat challenging to survey. As such, they have been identified amongst the highest priority species for research and monitoring (2016-18 SDJV Implementation Plan). Recent studies using PTT devices have shown that the breeding range of all three scoter species falls largely outside of the survey area of the Waterfowl Breeding Population and Habitat Survey (WBPHS - Traditional and Eastern Waterfowl Survey areas; SDJV 2015). Relatively little information on waterfowl and other migratory birds distribution and trends exists in this area encompassing the northern Boreal forest, the continuous tree line and sub-Arctic tundra of North America, where the influence of global climate change are expected to be important. Finally, there are also issues related to timing of the survey as the WBPHS is timed for early nesting dabbling ducks, primarily mallards (*Anas platyrhynchos*) and American Black ducks (*Anas rubripes*), whereas scoters are considered to be a later-nesting species.

Despite these difficulties, progress has been achieved as experimental scoter surveys in the Northwest Territories, Nunavut, Labrador, the Hudson Bay Lowlands and Northern Québec have confirmed the feasibility of conducting aerial surveys in remote Boreal and sub-Arctic regions of North America, as well as having identified key methodological gaps or biases requiring additional research. We propose to conduct experimental fixed-wing and helicopter integrated breeding surveys over portions of the ranges of all three scoter species in North America. This work, which will draw heavily on previous experimental work supported by the SDJV and partners, is expected to enable us to make recommendations on the appropriate methodology, potential costs and feasibility of implementing operational continental breeding ground scoter surveys. A secondary objective of the proposed work is to produce habitat selection models from the data collected in the course of the experimental surveys. This product will provide more detailed information on the distribution of breeding scoters across the landscape and should provide the information required to develop a cost-efficient stratified sampling approach. It will also be useful in Land Use Planning and Environmental Assessment in the proposed survey areas where little information on waterfowl distribution is currently available.

This project will address two SDJV priority science needs:

Specifically, this project will contribute to priority need #1 by focusing on evaluating geographic and annual variation and extent in the following parameters, from both fixed-wing and helicopter survey platforms:

- Detection probabilities
- Species identification /composition
- Differences in availability bias between the two platforms (i.e. correction factor to apply to platform with lower detection probability)

This work is expected to enable us to develop survey methods that allow for survey and observer specific corrections.

The proposed work will also contribute to the ongoing WBPHS review by addressing issues of current coverage relative to new information on the distribution and abundance of waterfowl outside the survey area, and in the consideration of reallocation of survey effort and timing to expand the usefulness of the survey for monitoring northern nesting species. We expect this work to result in a recommendation document for the establishment of a continental scoter breeding ground survey which would allow Canadian and U.S Federal agencies to determine the feasibility and appropriateness of expanding the WBPHS to cover core scoter areas.
The habitat modelling component of the proposed work will also contribute to the review by providing more detailed distribution information within the experimental survey areas and a framework for expanding this approach to eventually cover a larger proportion of the range. Specifically, this will address priority #2 of the SDJV strategic plan: inform habitat conservation actions.

Finally, priority information needs for population estimates for eastern Surf Scoters and eastern Black Scoters outlined in the SDJV sea duck harvest assessment report will be partially addressed, as we will be able to provide estimates of abundance for the experimental survey areas and, ultimately, propose an approach for continental population estimation. Results from this study are expected to be broadly applicable for the development of breeding ground survey methodology for all scoter populations.

Methods

Survey Timing - Breeding chronology

We used results of brood surveys and satellite tracking to evaluate the timing of breeding for scoters. Brood surveys that included brood ages were used to estimate nest initiation dates by back-dating from brood age. The satellite telemetry data was used to determine arrival and departure times from breeding sites.

Brood surveys

We identified four sources of brood surveys. These included brood surveys conducted as part of an environmental assessment of the Great Whale Hydroelectric Project, Québec conducted in 1991 (Bordage et al. 1992), a brood survey of 25 km^2 plot near Goose Bay, Labrador conducted in 2007 (SGG unpublished data), notes to file made by W. Barrow (CWS retired) when scouting sites for pre-season banding operations, 1990 to 1992 and the Avifauna Component Study for the Lower Churchill River (https://www.ceaa-acee.gc.ca/050/documents_staticpost/26178/31993/te-af-02.pdf) .

All broods were aged by plumage development (Gollop and Marshall 1954). Broods were aged using mid-points for plumage age classes for Surf Scoters described by Lesage et al. 1996. Nest initiation dates were calculated by back-dating the brood's age from the date of the observation minus 7 days, one day for the female to lay each egg in an average Surf Scoter clutch (mean = 7 eggs; Morrier et al. 1996).

Satellite Telemetry Data

We accessed the SDJV's satellite telemetry database in August 2017 and downloaded the unfiltered telemetry data for the period that included spring migration, breeding and arrival at molt (1 April to 1 September) for all Surf, Black and White-winged Scoters from eastern North America that were in the database. We also accessed telemetry data from scoters collected in western North America that were provided by Jason Schamber. We are seeking access to other datasets. Sources of the tags used in the analyses are identified in Appendix 1.

The migration tracks for each bird were mapped and labeled by year. Tracks for each year/bird combination were visually classified as: 1) Breeding - if they migrated to a breeding area and settled, 2) Possibly Breeding - migrated to a breeding area but unable to determine if they settled, and 3) Not Breeding – did not migrate to a breeding area. All bird/year combinations that did not migrate to a breeding location were filtered from the dataset. For the remainder, we created a Google Earth KMZ file with the track and individual locations labeled with dates. Each track was examined in detail and we recorded if the bird appeared to settle on a breeding site, and if it did, the date of its arrival and departure from the site (See Fig. 1 for an example of the process). The arrival and departure dates were merged with the telemetry data, and locations outside this period were filtered from the data. For each bird/year combination that remained in the dataset we calculated the mean breeding location using the function geomean (Package Geosphere; Hijmans 2016) and determined the province of each breeding attempt.

We examined data tagging effects for female Black Scoters that attempted to breed in the year they were tagged and that also attempted to breed in subsequent years. Arrival dates averaged about 2 weeks earlier (9 June ± 10d, n=32) in the year subsequent to tagging than in the year of tagging (23 June ±13d, n=28); there was no effect of tagging on departure dates. Hence, we excluded all observations made in the year of tagging from the analysis, and for individuals that had observations for multiple breeding seasons we used only one season per bird. We summarized arrival and departure dates, and length-of-stay by species, sex and province that the breeding attempt occurred.

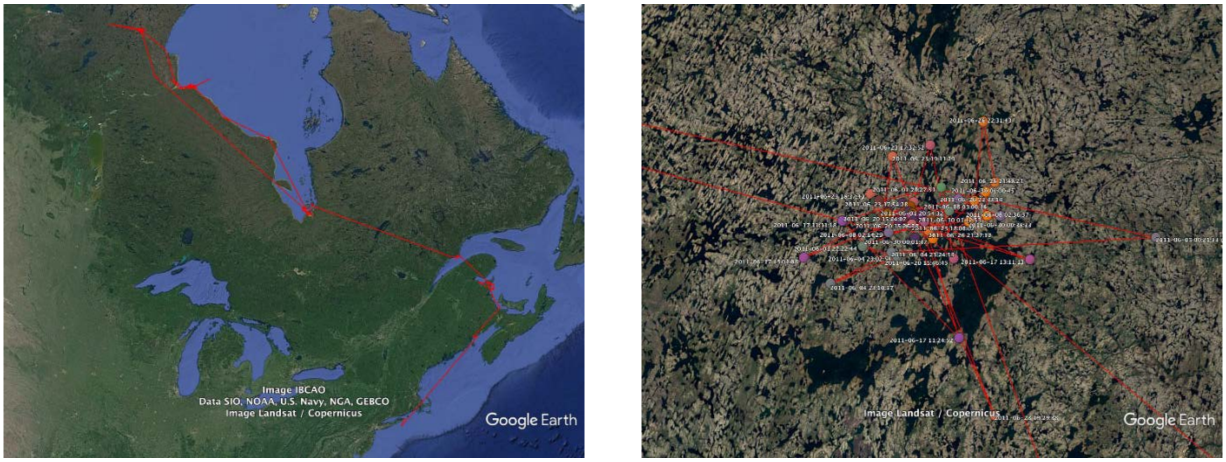

Figure 1. Spring migration track for female Black Scoter 39082 in 2011 (left panel) and visual confirmation that it settled on the breeding area from its arrival on June 6th until departure on July 6th (right panel).

Site Selection

To select survey areas, we used telemetry data from the SDJV’s satellite telemetry database to delineate the breeding habitat of female scoters. The database was filtered to identify females that went to a breeding area. For each of the females that settled during the nesting period, we assigned a spatial data point that was associated with the area where the females spent most of her time. These spatial points were subsequently used to identify the habitat that the female selected for breeding. Given that we had presence only data (i.e. points where we knew the females were breeding) we used a Maxlike approach to estimate the probability of occurrence of breeding females (Lele and Kleim 2006; Royle et al. 2012). We used the Land Cover Map of Canada and multi-spectral remote-sensed data at a 1-km resolution to make spatial predictions (Fig. 2).

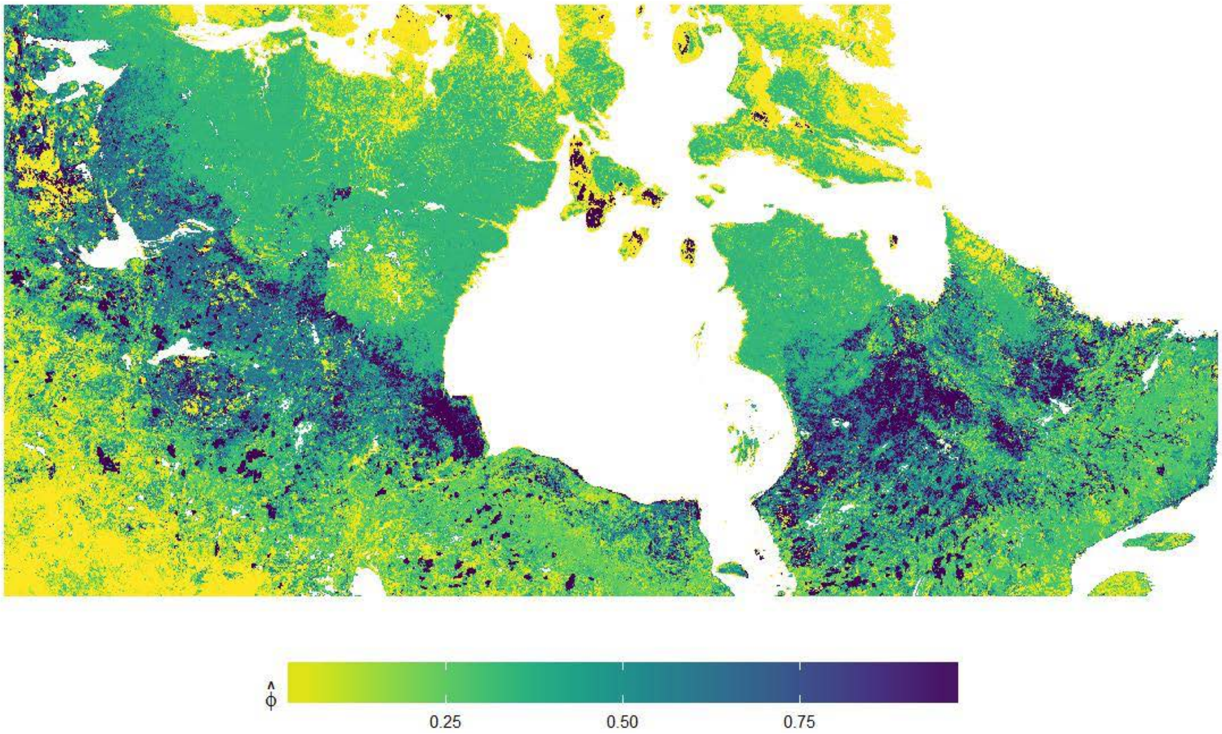

Figure 2. Probability of occurrence for breeding scoters predicted from breeding locations of scoters estimated from satellite telemetry data from eastern scoters and land cover.

2017 - Based on these habitat models, we made predictions of scoter occupancy for the entire Canadian Subarctic region and we selected 4 possible survey areas. Those survey areas were located along the Boreal transition zone in the NWT, Nunavut and Manitoba. We subsequently selected one site in Northern Manitoba (Figure 4), and one in the Northwest Territories (Figure 5) based on logistical constraint for helicopter surveys (i.e. access to lodging and fuel caches). A third survey area was included in the Northwest Territories given that it is under consideration for receiving legal designation as a protected area (Figure 6).

2018 - Predictions of scoter densities for the entire Canadian Subarctic region, based on 2017 survey results and habitat selection models, were run for 5 new possible survey areas selected for consideration. We selected 1 of these based on occurrence and predicted densities of the three scoter species, scaup and Long-tailed Ducks, as well as logistical and financial constraints (e.g. presence of an air strip for landing for the fixed-wing and more cost effective to work out of a large city than from a remote camp). We also resurveyed 1 of the 3 sites surveyed in 2017 in order to assess interannual differences. Thus, 2 sites, Lynx Lake (Figure 5), and Yellowknife (Figure 7) were surveyed both by helicopter and by fixed-wing.

Helicopter Component – Sampling Design

The surveys were conducted at the northern edge of the boreal forest (Figure 3). The landscape in this region is highly diverse, being covered with wetlands, coniferous forest, and open tundra. Given the level of heterogeneity present on the landscape, obtaining a representative sample in the survey area can be challenging. Analysis of previous waterfowl surveys conducted in the northern boreal forest demonstrated that using a simple random and systematic designs, resulted in poor coverage of some of the potentially important but rare habitats (Roy et al. *unpublished data*) so we opted for a stratified-random sampling design. We first divided our sampling areas into cells of 5 x 5 km (size of the plots to be surveyed). We then developed three weighting indices to select the sample. The first index was based on landscape composition within each cell. We averaged the Z-score values for the habitat variables that were identified as important for waterfowl habitat in the boreal forest (number of lakes, lake area, shoreline index, river density and proportion of coniferous forest). This index gave us an idea of how representative each possible sampling site (i.e. grid cell) was for the survey area. Cells with an average Z-score near zero were representative of the survey area, while cells with a high or low averaged Z-score were identified as unique. The second weighting variable was composed of the predicted total indicated pairs of Black Scoter and Surf Scoter within each cell. The predictions were based on a habitat model that was developed from previous surveys in Labrador and Northern Quebec (Roy et al. *unpublished data*). These predictions were based on the same habitat models that were included in the Z-score index.

Given that our objective was to obtain a sample as representative as possible, we divided the posterior distribution of each of the weighting variables into 5 categories (very low, low, average, high, very high) and calculated the proportion of each cell in each of these categories. Each cell was subsequently assigned a score value equal to the proportion to which they belong. We then averaged the scores across all three weighting variables (Z-score, predicted Black Scoters IP, and predicted Surf Scoters IP). The combined scores were then divided into 5 categories and applied a sampling procedure that insured that all categories were represented in the sample. We proceeded to draw a sample of 20-30 sites for each sampling area and scored the data set for its spatial coverage of the survey area, representing a sampling intensity of approximately 2.5%. Maintaining adequate spatial coverage ensured that we would be able to detect any spatial pattern present in our habitat model that would not be explained by explanatory variables. If the sample of selected sites was too clumped it was rejected and another sample was drawn. Any set that contained an immediate neighbor was also discarded. We repeated the sampling procedure in each area until we found a data set that respected these conditions.

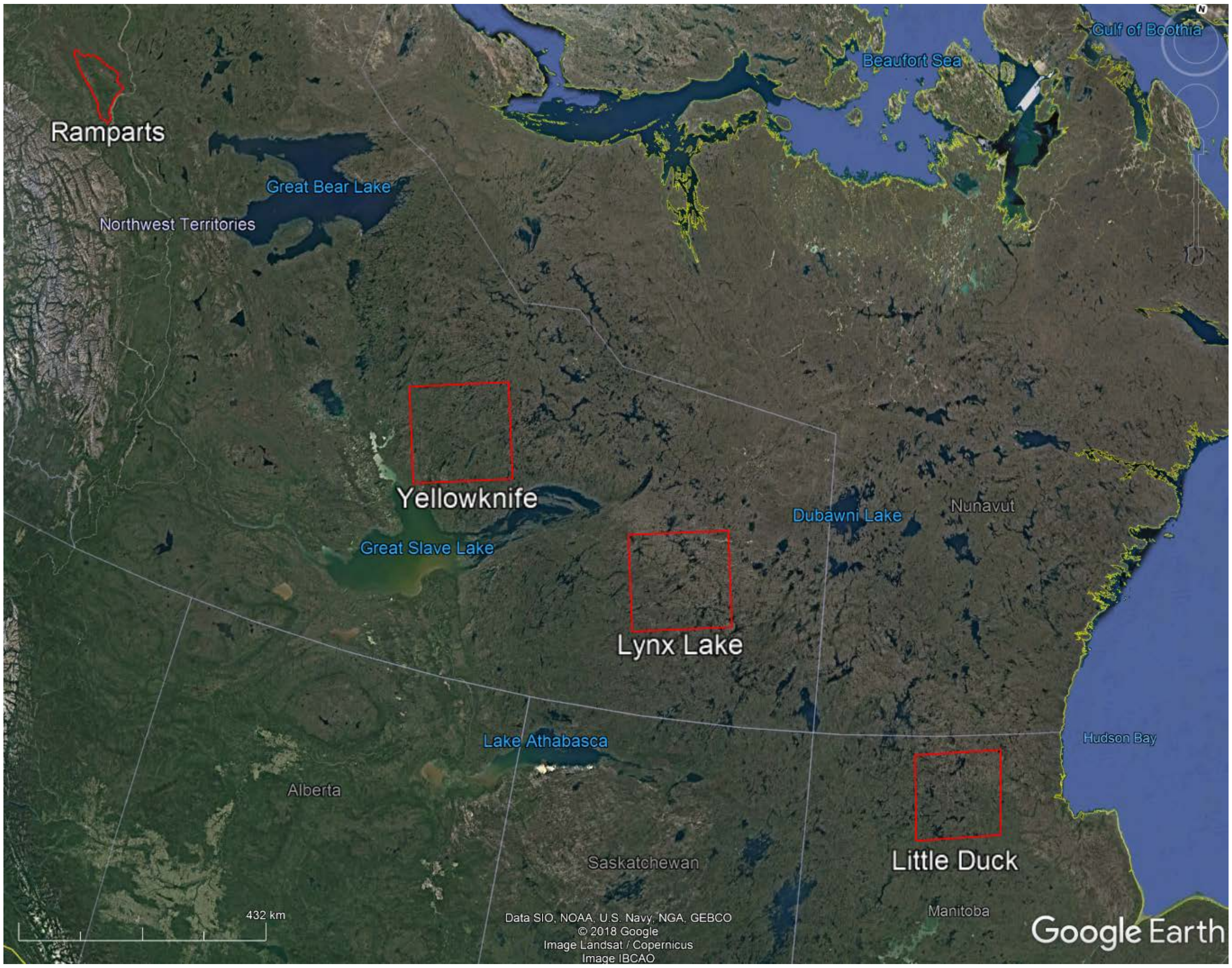

Figure 3. Overview of the 2017 and 2018 survey areas in northern Canada. The area of each site was: 2017: Lynx Lake = 21,750km^2, Little Duck = 18,225km^2, Ramparts = 4,692 km^2, 2018: Lynx Lake = 21,750km^2, Yellowknife = 20,300km^2.

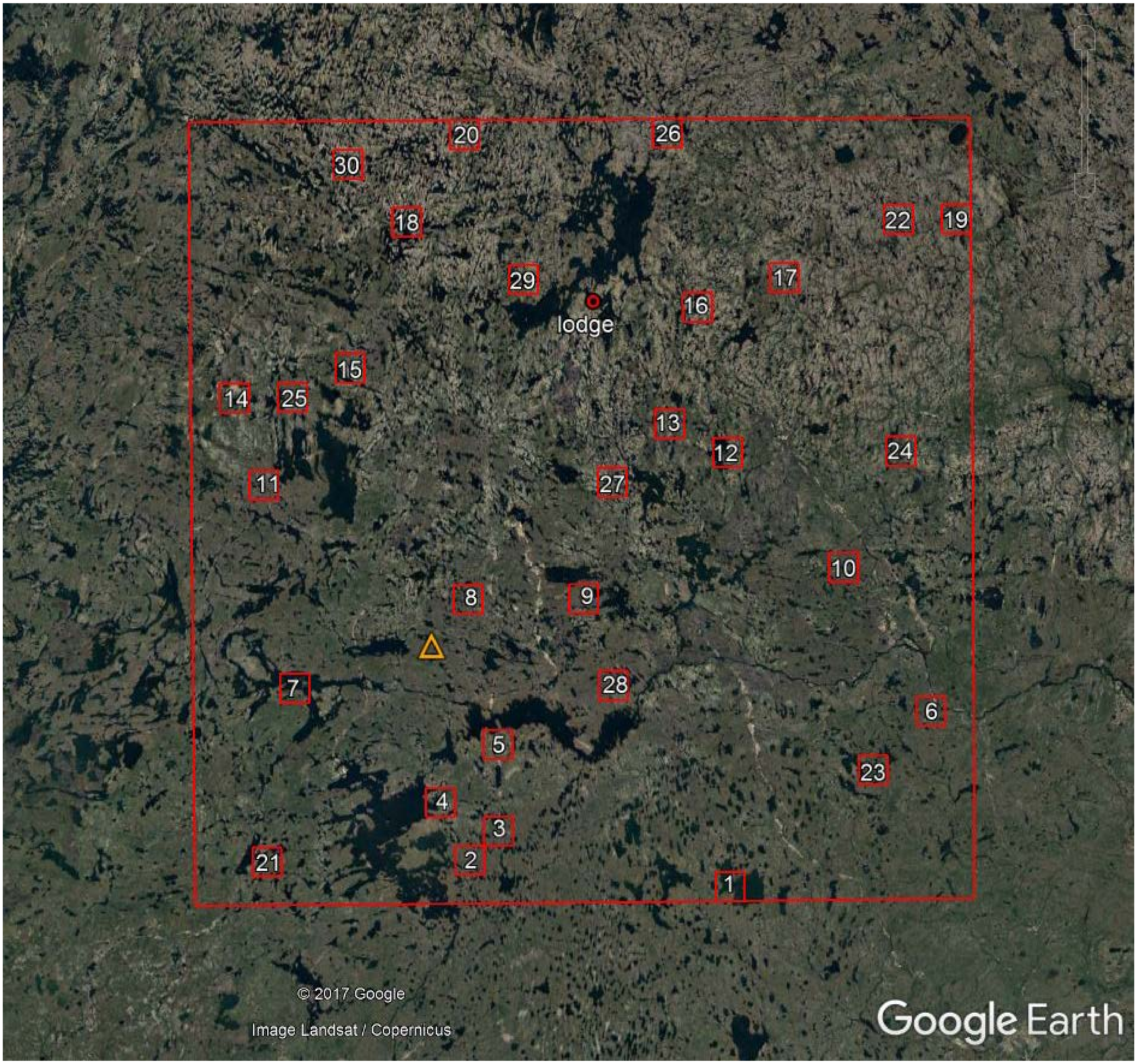

Figure 4. The Little Duck Lake survey area in northern Manitoba, Canada. Plots 1 to 24 and 26 were surveyed in June 2017.

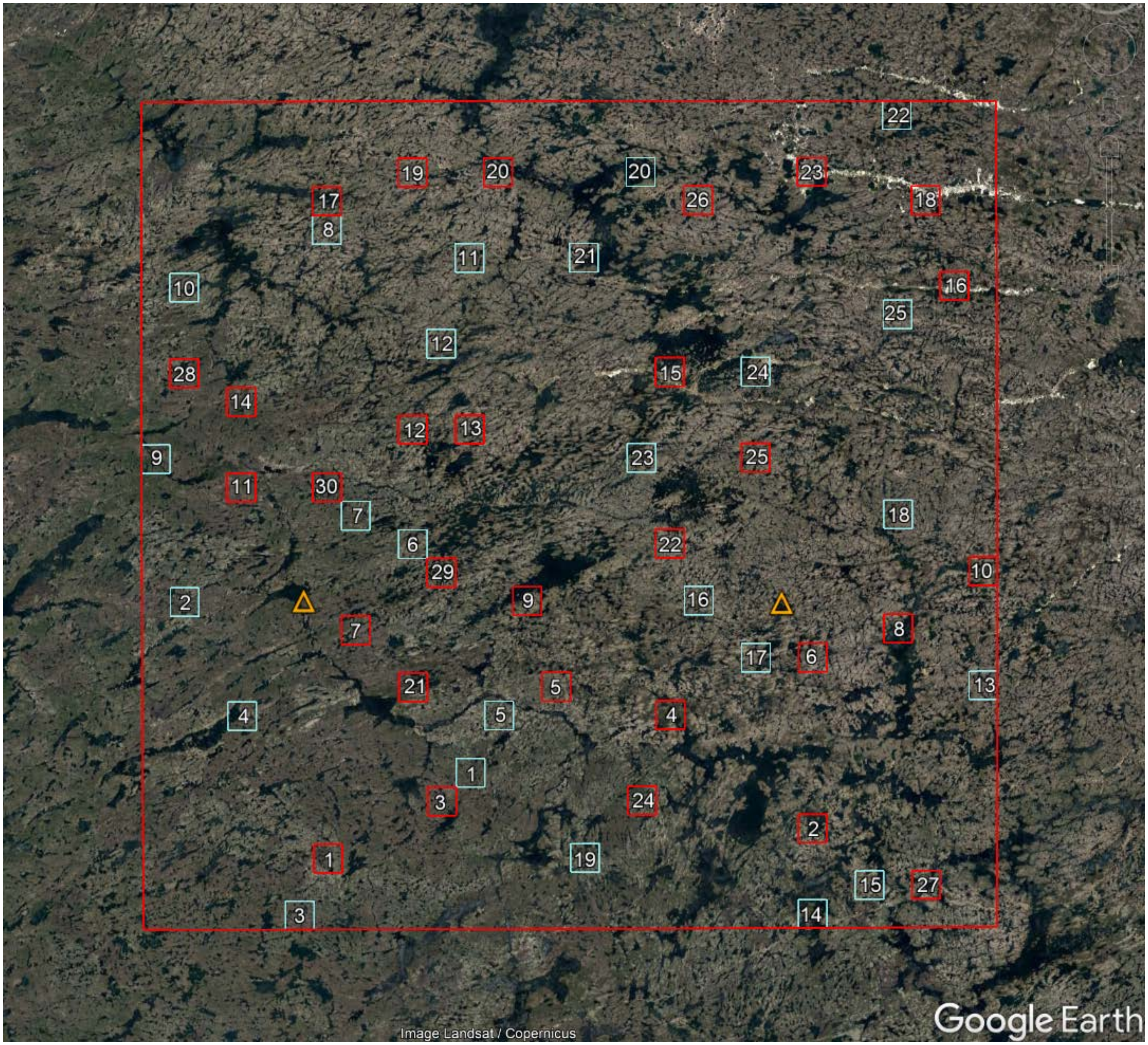

Figure 5. The Lynx Lake survey area in southeastern Northwest Territories, Canada. Plots 1 to 26 (red squares) were surveyed in June 2017. Plots 1 to 25 (light blue squares) were surveyed in June 2018. Triangles represent fuel caches

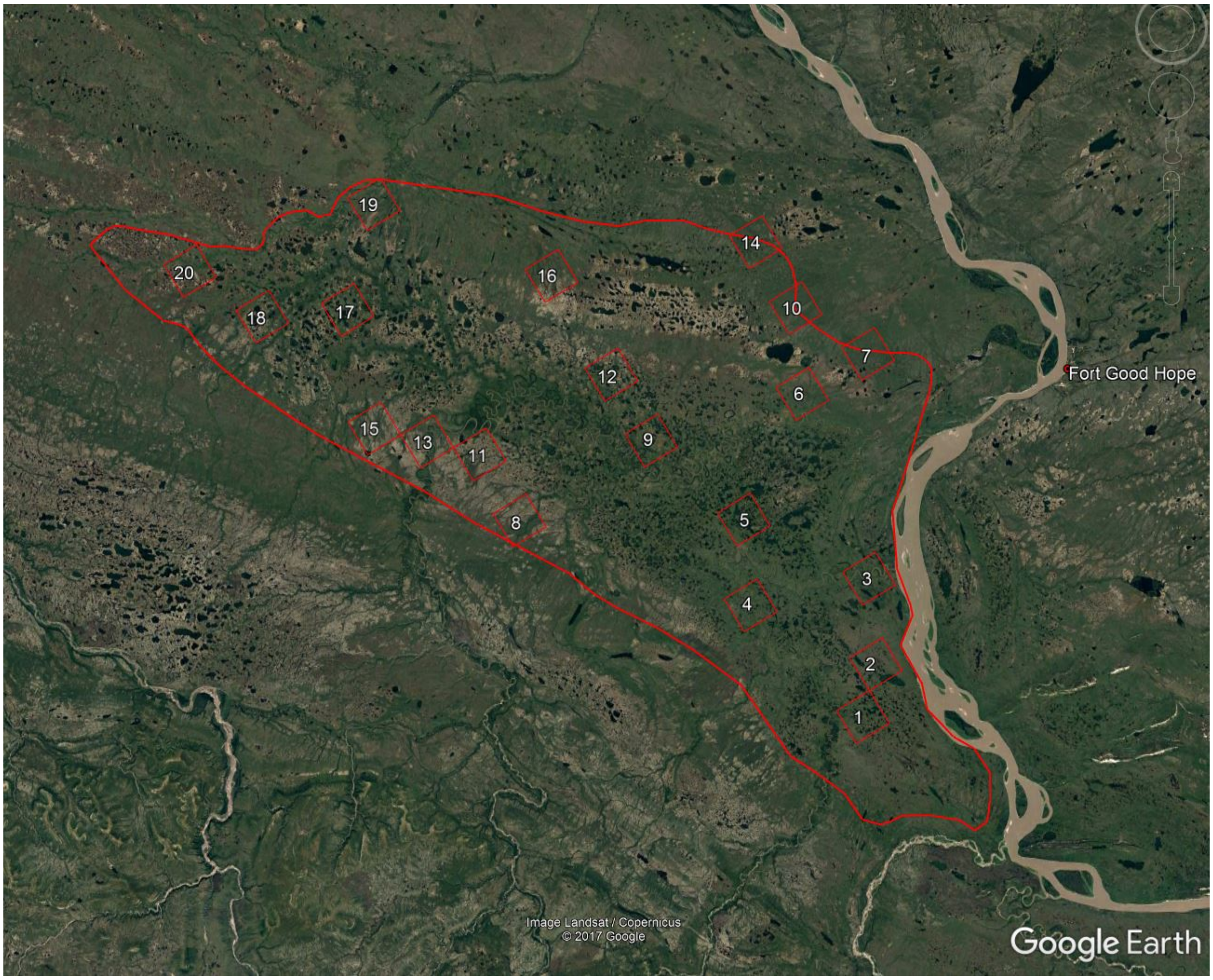

Figure 6. The Ramparts survey area in northwestern Northwest Territories, Canada..

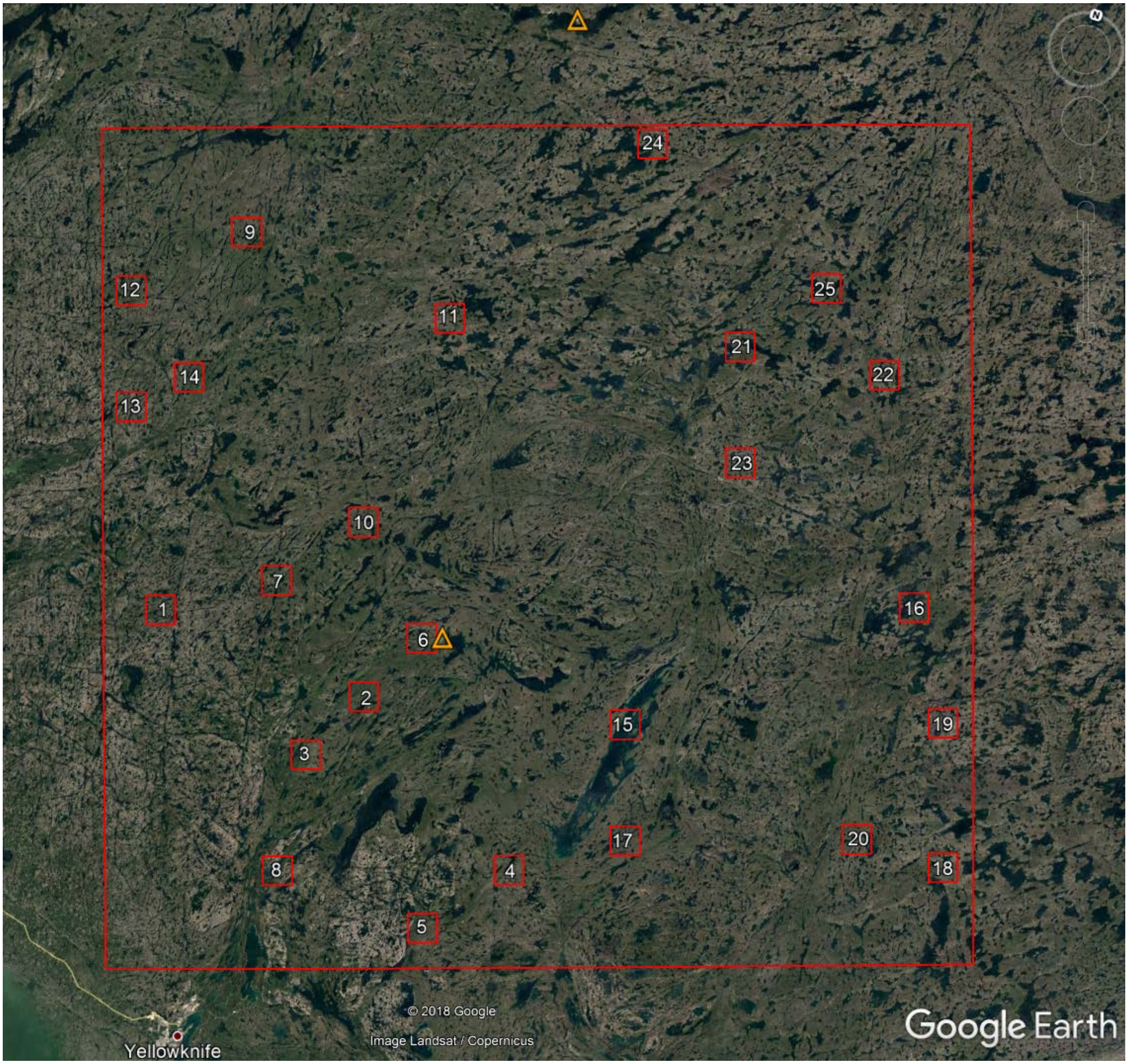

Figure 7. The Yellowknife survey area in central Northwest Territories, Canada. All 25 plots were surveyed in June 2018.

Fixed-wing Component – Sampling Design

In both survey areas we systematically placed 12 transects 14 km apart. To make navigation easier, the transects were placed on a straight east-west bearing (Figure 8 and 9).

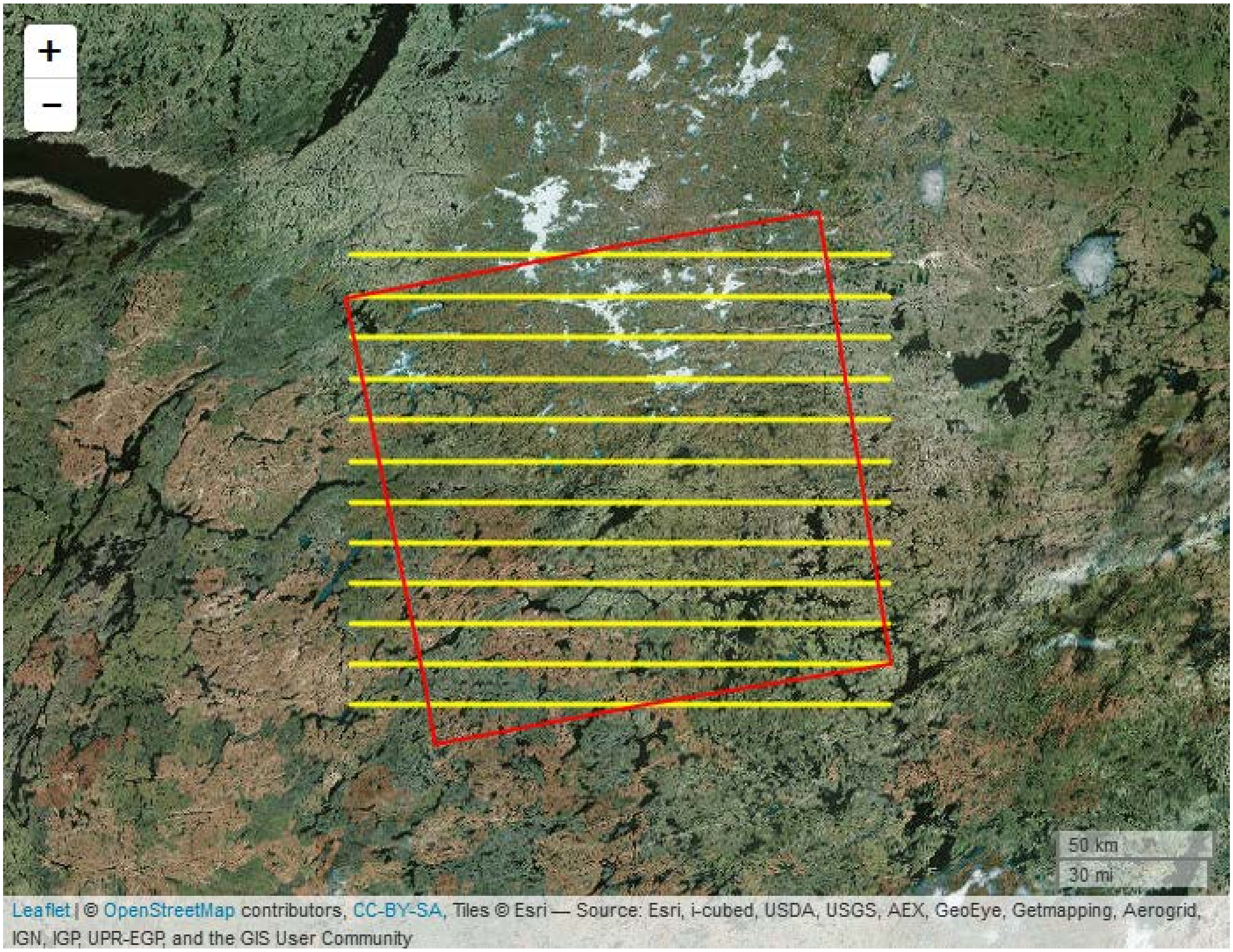

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Figure 8. Location of fixed-wing aircraft transects (yellow lines) over the Lynx Lake study area (red square) in 2018.

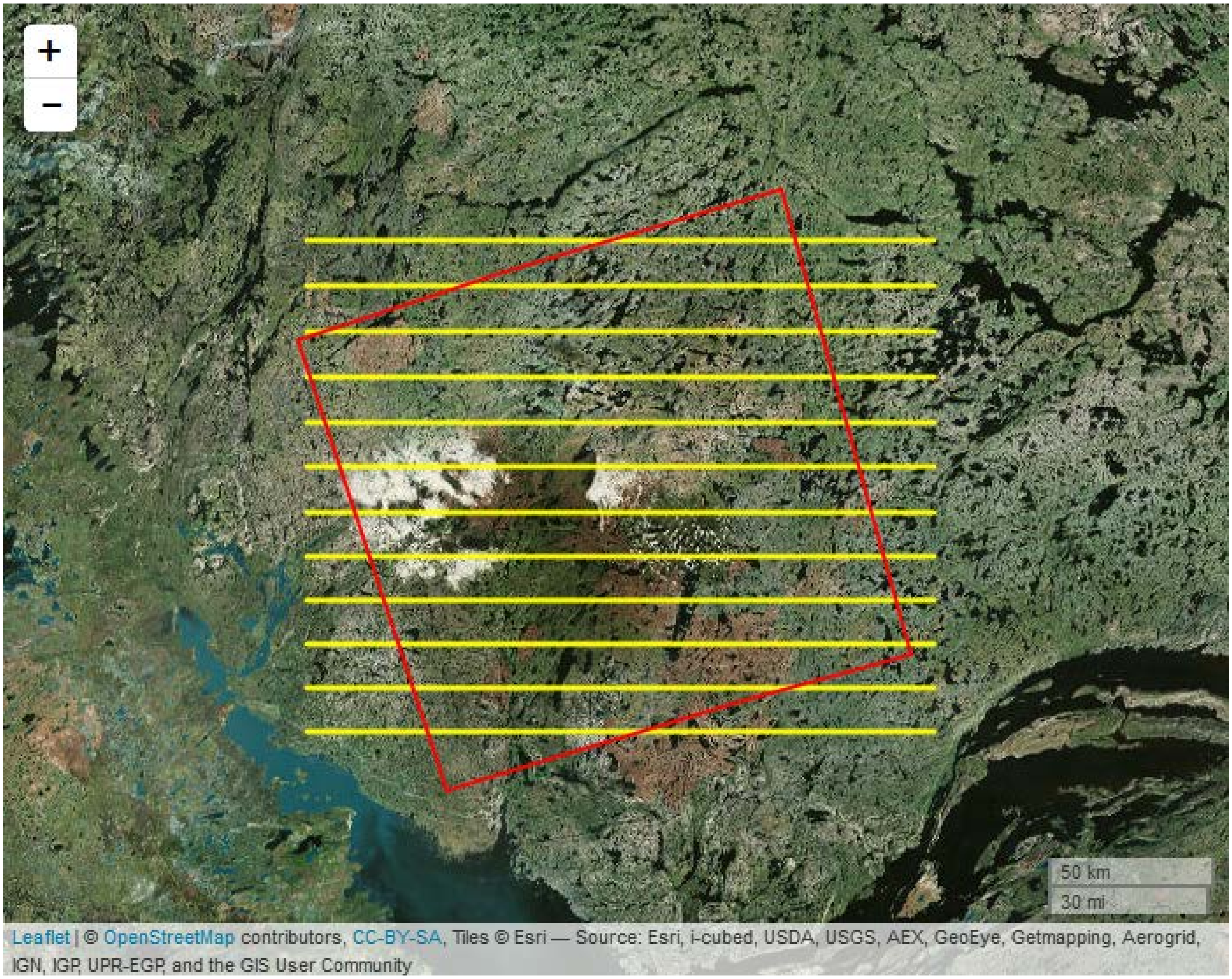

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Figure 9. Location of fixed-wing aircraft transects (yellow lines) over the Yellowknife study area (red square) in 2018.

Survey Protocol -*Helicopter*

In all 2017 and 2018 study areas, surveys were carried out in a Bell 206LR helicopter equipped with popout floats and rear bubble windows to enhance observer visibility. Exceptions to that were in Ramparts in 2017, the helicopter available was a Bell 407 equipped with skids but it did not have bubble windows, and in 2018, the Bell 206LR contracted for the Yellowknife site had wedge windows. Surveys took place in favourable weather; flights were delayed if wind speed exceeded 40 km/h, if precipitation occurred on more than 10% of the plot, or if visibility was reduced. Surveys were conducted throughout the day but began no earlier than 08:00 and ended no later than 18:00 to avoid poor light conditions. The survey crew consisted of the pilot and one observer in the front and two observers in the rear of the aircraft. During the survey, the helicopter flew over all water body shorelines, watercourses, and wetlands within the plots. Depending on the habitat and topography, surveys were flown at 15–50 m above ground level and at speeds ranging from a hover to 70 km/h. For all waterfowl observations the count, species and location of the observations were recorded by either the front observer or a rear observer, depending on crew, via a GPS-Voice recording software. Image stabilising binoculars and/or photos were used to aid in identification.

Double Observer Protocol

To assess detectability, we used a double dependent observer sampling scheme. In this sampling scheme, one observer is designed as the “primary” observer and the other as the “secondary” observer. The primary observer reports all his observations to the secondary observer. The secondary observer reports all observations that are missed by the primary observer. We alternated the roles between primary and secondary observers at each plot. The original double-counting procedure was modified to accommodate the constraint imposed by making observations from a helicopter (see Gilliland et. al 2010). Observations from the two front observers and two rear observers were combined and treated as a single observer. An imaginary line was drawn through the helicopter, perpendicular the direction of travel and between the front and rear observers. The primary observer was only allowed to record his observations when he detected forward of this line. Observers were allowed to redirect the helicopter path to ensure that the age and sex of the birds were classified accurately. However, any additional observations that were made while the helicopter was being redirected by one of the observers (i.e. observations that were missed by both observers on the first pass) were recorded as not detected. In some cases one observer in a crew was inexperienced with the helicopter survey protocols. Therefore, to avoid confounding the observer’s position with observers’ experience in our modeling exercise, the front seat observer was occupied by one of the two other experienced observers, switching position and role amongst themselves. At the end, the two experienced observers spent approximately equal time in each detection roles, and approximately equal time in the front or rear position.

Survey Protocol –Fixed-wing

In 2018, fixed-wing surveys were carried out in a USFWS Quest Kodiak equipped with wheels. Strip width distance was 200 m from the center of the plane. The strip was divided into 2 distance bands (inner and outer bands of ~100m each). Observers used a clinometer to calibrate the sighting angle required for a flight altitude of 40m and straight flight (i.e., without crab). We used a 4-person crew for the entire survey. With 4 observers, the rear observers switched sides so about half of the survey is flown on the left and half on the right side of the aircraft. Each observer had a USFWS GPS Voice Recording System (J. Hodges, unpublished Software) which allowed the observer to collect an audio recording, and time and location of the recording. For each detection, observers recorded species (to the lowest taxonomic level possible), social structure (sex composition) and the distance band.

Double Observer Protocol

To assess detectability we used independent double counting sampling scheme. The rear observers switched side of the aircraft within and between days such that about a quarter of the survey was flown with each combination of front and rear observers. This design will allow us to determine if observer fatigue may have an effect on detection.   We will estimate detection for the fixed-wing using the unreconciled double-observer method for estimating detection probability and abundance (Riddle et al. 2010).

Phenology Index

To determine survey timing relative to nest initiation, we calculated a phenology index (PI) (see Dzubin 1969, Bordage et al. 2017). This index is the ratio of the number of pairs to male only groups (lone males and flocked drakes). For species where the sex ratio is near unity, a PI near 1.00 suggests about half of the females are attending their nest, and unavailable to be detected, while the other half are attended by males and available to be detected. A PI value much greater than 1.00 indicates a survey conducted before the peak of nest initiation, and a small PI indicates a survey conducted after the peak, and or, there is a male biased sex ratio.

Density Estimation

We developed a three-step model to estimate detection. Given that most of the birds are observed in pairs or in groups we used the cluster as the unit of observation (Sollmann et al. 2016). The first step was to estimate the detection rate of the clusters of birds that were detected during the survey. The second step estimated the “true” numbers of clusters, corrected for incomplete detection, that were present in a given site. Finally, the third step was to estimate the size of the undetected clusters based on the size of the clusters observed in the survey area. Each component of the detection model is explained in detail below.

Cluster Detection Model

Let $y_{1_{i,j}}$ and $y_{2_{i,j}}$ be the numbers of clusters of birds detected by the primary observer and secondary observer respectively and $y_{T_{i,j}}$ be the total number of birds detected by both observers in plot *i* for a given species *j*. The dependence between counts of primary and secondary observers may be specified using a multinomial model such as:

$$y_{1:2_{i,j}} \sim \mathit{Multinomial}\left(p_{1_{i,j}}, \left(1 - p_{1_{i,j}}\right) p_{2_{i,j}}\right) \qquad \text{Eq. 1}$$

where $p_{1_{i,j}}$ and $p_{2_{i,j}}$ denote the detection rate of primary and secondary observers for a given species *j* while surveying the plot *i*. Given the observers detection rate, the total detection rate for a given species in a plot can be calculated as $p_{T_{i,j}} = 1 - \left(1 - p_{1_{i,j}}\right)\left(1 - p_{2_{i,j}}\right)$ and the true number of clusters in the the survey plot ($C_{i,j}$) can estimated via a binomial distribution such as:

$$C_i = \text{Binomial}\left(y_{T_{i,j}}, p_{T_{i,j}}\right) \qquad \text{Eq. 2}$$

The sources of variation in detection rates during the survey for the pairs of observers k can be assessed via a logistic link:

$$\text{logit}\left(p_{k_{i,1:j}}\right) = \alpha + \beta\mathbf{X} + \gamma_1 \text{Seat}_i + \gamma_2 \text{Observer}_i \qquad \text{Eq. 3}$$

$$\beta_j \sim \text{normal}\left(0, \sigma_\beta^2\right) \qquad \text{Eq. 4}$$

where α in the intercept, β is a species specific effect, **X** is a matrix that contain the species identity, γ_i is the effect of the position of the observer in the helicopter, and γ_2 is the effect of the secondary observer. We modeled the species specific effect as a random effect where the variance parameters σ_β^2 specify the levels of variation in detection rate among species.

Cluster Abundance

We estimated the variation in cluster abundance via a compound Negative binomial distribution with a quadratic mean–variance relationship (i.e. NB2; Hilbe 2014) distribution. This distribution is parametrized in function of the mean μ and an overdispersion parameter:

$$C_{i,j} \sim \text{Negative Binomial}\left(\mu_j , \kappa_j\right) \qquad \text{Eq. 5}$$

$$\log\left(\mu_j\right) = \alpha_j + \log(\text{Area}_i) \qquad \text{Eq. 6}$$

$$\alpha_j \sim \text{Normal}\left(0, \sigma_\mu^2\right) \qquad \text{Eq. 7}$$

$$\kappa_j \sim \text{Lognormal}(0, \sigma_\kappa^2) \qquad \text{Eq. 8}$$

where $C_{i,j}$ is the expected numbers of clusters in plot *i* for species j, μ_j the mean abundance of clusters in the survey area for a given species, κ is the overdispersion parameter for a given species, and α is the expected number of clusters on the log scale. The species specific expected number of clusters on the log scale and overdispersion parameter were both modeled as random effects across species.

Cluster Size Model

The last step of the model was to estimate the size of the missing clusters (i.e. the number of ducks in a flock). To that end, we have used a data augmentation scheme. For each species we created a vector containing the size with the observed clusters and padded the vector with missing entries. Those missing entries act as surrogates for the missed observations. Given that the distribution of the size of the clusters for species did not follow a unimodal distribution we opted to model the distribution of the cluster size via a categorical distribution. We used the largest seen cluster as the upper bound (M) for the categorical distribution. The probability of occurrence of each cluster size (ψ) was derived from a Dirichlet distribution.

$$\text{Birds}_{j,k} \sim \text{Categorial}(\psi_{1:M}) \quad \text{Eq. 9}$$

$$\psi_{1:M} \sim \text{Dirichelet}(\alpha_{1:M}) \quad \text{Eq. 10}$$

$$\alpha_{1:M} = 1/M \quad \text{Eq. 11}$$

We derived the total abundance for a species (T_j) in the survey area by summing over the size of all clusters across the sites. To avoid including too many clusters in the sum we used the total number of cluster predicted in the area as the upper bound of the summation.

$$T_j = \sum_{k=1}^{C_j} Birds_k \quad \text{Eq. 12}$$

We estimated the parameters using a Bayesian framework that was implemented in JAGS (Plummer 2003) from R using the jagsUI package (Kellner 2016; R Core Team 2013). We used non-informative priors for all parameters and we ran five chains with randomized initial values for 25,000 iterations, with the first 5,000 iterations used as a burn-in and saved every 20th iteration. Chain convergence was visually evaluated and verified using the Gelman-Rubin statistic ($\hat{R}$) with both measures indicating a reasonable assumption of convergence. We used the sums of the squared Pearson residuals to assess the model fit via posterior predictive checks (Kéry 2010) and did not find any evidence of lack of fit for the model. We report results as posterior means and 2.5 and 97.5 percentiles of the posterior distribution for credible intervals (95% BCI). For the discussion, we consider covariate effects as strong/significant if their 95% BCI do not overlap 0.

Habitat Selection Model

We used two major data sources for extracting explanatory variables. The CanVec database (v 6.18), a digital cartographical reference at the 1:50000 scale which is distributed by the Centre for Topographic Information, Natural Resources Canada (http://geogratis.ca/) and Ducks Unlimited Canada's Hybrid Wetland Layer, a raster layer that classifies the Canadian land base into three general categories: Water, Wetland, and Upland (Jones 2011).

Based on the previously published literature we extracted the following variables from the geographic data source: the numbers of lakes in a given cell, the average lake size, the variance in lake size, total shore length, total river length, the proportion of the cell covered by open water, wetlands and coniferous forest. We derived a shoreline index from the total shore length, the average lake size and the total number of lakes in a cell. A value of 1 indicates that the amount of shoreline in the cell equal to the amount of shoreline there would be if all lakes in the cell would be perfect circles, a value above 1 indicates more complex shoreline, and a value below 1 indicates that there is less shoreline than expected in the cell. The latter situation could arise, for example, if the cell is covered in part by a large lake.

Multicollinearity among predictor variables is often a problem with landscape metrics. We therefore used a variance inflation factor approach (VIF) to select a subset of explanatory variables to use for our model. We used a threshold of 2.5 for the VIF. Based on the output of the different permutations possible we ended up keeping 6 explanatory variables: The number of lakes on the log scale, the total lakes area on the log scale, the shoreline index, the proportion of wetlands, and the proportion of coniferous forest in the landscape. We felt that the combination of 6 variables would be the best combination to capture the variability in both survey areas, maintain collinearity between variables to an acceptable threshold, while also having sufficient explanatory power to explain the distribution of species of ducks that could have different habitat requirement.

During the preliminary screening of the data, some species showed a quadratic correlation to some of the selected variables. We therefore built a candidate set of models that contained the 64 possible combinations of quadratic terms in the model. We fitted all the models to each species and we used bridge sampling to estimate the likelihood ratio between the models (Meng and Wong 1996, Gelman and Meng 1998).

For each species we estimated the Indicated breeding pairs (IBP) associated with each sampling sites. We estimated the variation in waterfowl IBP in the sampling sites via a negative binomial model (ZINB).We used the Negative binomial distribution with a quadratic mean–variance relationship as the probability distribution explaining the abundance of IBP at survey sites (i.e. NB2; Hilbe 2014). This distribution is parametrized in function of the mean and an over-dispersion parameter such as:

$$\mathrm{IBP}_i \sim \mathrm{NB}(\eta_i, \kappa) \qquad \text{Eq. 13}$$

$$\log(\eta) = \mathbf{X}\beta + \log(\mathrm{area}) \qquad \text{Eq. 14}$$

where IBP_i is the number of pairs at site *I*, η is the expected mean of IBP at location *I*, κ is the over-dispersion parameter, **X** is matrix holding the explanatory variables, and β is a vector holding the estimate of the effect of the explanatory variables. We included the log of the sites' area as an offset in our analysis. The explanatory variables were standardized to zero mean and unit variance to ease interpretation and convergence of the model (Kéry 2010).

We ran the series of models for each species independently in a Bayesian framework that was implemented in Stan from R using the rstan package. We used a non-informative prior for all parameters and we ran four chains with randomized initial values for 1500 iterations, with the 500 first iterations used as a burn-in. Chain convergence was visually evaluated and verified using the Gelman-Rubin statistic ($\hat{R}$). We used the package bridgesampling (Gronau and Singmann 2017) to estimate the model posterior probability and retained the model with the highest probability for each species. In the results section we present the posterior means and 2.5 and 97.5 percentiles of the posterior distribution for credible intervals (95% BCI). For the discussion, we consider explanatory variables effects as "significant" if their 95% BCI do not overlap 0 and "weak" if their 90% BCI do not overlap 0.

Preliminary Results & Discussion

Survey Timing - Breeding Chronology

Brood Surveys

We obtained data for 77 scoter broods from Labrador and Québec. Nest initiation dates average between 26 May and 1 June depending on species and location (Table 1).

Satellite Telemetry Data

To date we have processed all the telemetry data from birds tagged in eastern North America for Black Scoter (Table 2 and 5), Surf Scoter (Table 3 and 5), and the eastern White-winged Scoters (Table 4 and 5). Telemetry data from birds tagged in western North America have been requested but we have not received the data.

Table 1. Nest initiation dates estimated for scoters in Québec and Labrador from back-dating age of broods observed.

Area	Species[1]	Nest Initiation ± sd (n)
Labrador	SUSC	1 June ±9 (51)
Labrador	BLSC	3 June ±4 (2)
Québec	Scoter	28 May ±7 (10)
Québec	SUSC	27 May ±6 (7)
Québec	BLSC	26 May ±9 (7)

[*] BLSC, Black Scoter; SUSC, Surf Scoter

Table 2. Arrival and departure dates for Black Scoters tagged in eastern North America estimated from satellite telemetry.

Area	Sex	Arrival	Departure	n
Manitoba	F	5 Jun ±3	26 Jul ±3	5
Manitoba	M	5 Jun ±6	21 Jun ±12	8
Labrador	F	8 Jun	NA	1
Northwest Territories	F	11 Jun ±6	14 Aug ±18	9
Northwest Territories	M	30 May	26 Jun	1
Nunavut	F	16 Jun ±12	4 Aug ±10	5
Nunavut	M	7 Jun ±5	3 Jul	2
Ontario	F	27 May ±8	NA	2
Quebec	F	9 Jun ±14	30 Jul ±11	10
Quebec	M	1 Jun ±8	23 Jun ±2	3
Overall	F	11 Jun ±10	4 Aug ±15	27
Overall	M	3 Jun ±7	24 Jun ±11	9

Table 3. Arrival and departure dates for Surf Scoters tagged in eastern North America estimated from satellite telemetry.

Area	Sex	Arrival	Departure	n
Manitoba	F	1 Jun ± 7	24 Jul ± 3	3
Manitoba	M	26 May ±12	14 Jun	2
Labrador	F	30 May ±6	26 Jul ± 13	8
Northwest Territories	F	10 Jun	20 Jul	1
Nunavut	F	1 Jun	20 Jul	1
Ontario	F	30 May	6 Jul	1
Quebec	F	29 May ± 5	18 Jul ± 16	16
Quebec	M	22 May ± 4	15 Jun ±9	3
Overall	F	30 May ± 5	21 Jul ± 11	30
Overall	M	24 May ± 7	15 Jun ± 7	5

Table 4. Arrival and departure dates for White-wing Scoters tagged in eastern North America estimated from satellite telemetry.

Area	Sex	Arrival	Departure	n
Manitoba	F	14 Jun ±11	2 Aug ±21	6
Manitoba	M	1 Jun ±0	20 Jun ±2	2
Northwest Territories	F	11 Jun ±9	22 Jul ±33	12
Northwest Territories	M	2 Jun	16 Jun	1
Nunavut	F	13 Jun ±3	28 Jul ±26	2
Ontario	M	11 Jun	03 Jul	1
Quebec	F	10 Jun ±10	24 Jul ±19	3
Quebec	M	7 Jun	NA	1
Saskatchewan	F	19 Jun ±0	2 Jul	2
Saskatchewan	M	4 Jun	29 Jun	1
Overall	F	12 Jun ±9	24 Jul ±27	25
Overall	M	4 Jun ±4	23 Jun ±6	6

Table 5. Average length-of-stay on the breeding site by species and sex of scoters estimated from satellite telemetry for scoters tagged in eastern North America.

	Species[1]		
Sex	BLSC	SUSC	WWSC
Female	47 days ±18 (60)	49 days ±14 (48)	43 days ±27 (34)
Male	18 days ±9 (22)	25 days ±15 (10)	24 days ±10 (8)

[1] BLSC = Black Scoter; SUSC = Surf Scoter; WWSC = White-wing Scoter; ±sd (n).

Phenology Index

The phenology index varied by year and location for all species (Figure 10, Table 6). In 2017, the phenology index suggested the timing of the survey, relative to nest initiation, was good for Surf Scoters at Little Duck Lake (0.89) and Lynx Lake (0.92) study areas, and possibly early in the Ramparts study area (4.18; Table 6). The surveys of Ramparts were completed earlier than the other study areas which may explain the higher phenology index value. The phenology index also suggested the timing of the survey for Black Scoter occurred within the nest initiation period at Little Duck Lake (0.91) and a bit before nest initiation at Lynx Lake (1.50), whereas the penology index for White-winged Scoters was above 3.00 in all three study areas, indicating that the survey may have occurred before many White-wing Scoters initiated egg-laying. The phenology index for Long-tailed Ducks suggested the timing of the survey was within the nest initiation period at Little Duck Lake (1.04) but may have occurred during late nest initiation and early incubation at Lynx Lake (0.62; Table 6). The phenology index was close to 1.00 for Lesser Scaup in all three study areas (from 0.81 to 0.97; Table 6) suggesting the survey occurred within the peak of nest initiation for these species. The phenology index was well below 1.00 for the dabbling species (American Green-winged Teal, Mallard and Northern Pintail) at most sites, suggesting that many of the males seen at these sites may have been post breeders.

Spring was delayed by more than two weeks in 2018 relative to 2017 and the phenology index for all three scoter species reflected this (phenology index range: 1.31 - 4075; Table 6) except for Surf Scoters in the Yellowknife study area, suggesting the survey occurred before the peak of nest initiation. In the Yellowknife study area, our surveys likely occurred after the peak of nest initiation for Surf Scoters (0.71) and before the peak for Black and White-winged scoters (2.08 and 4.75, respectively; Table 6). Lesser Scaup breeding phenology did not appear to be influenced by the later spring: the survey occurred around the peak of nest initiation at Lynx Lake (1.05) and slightly after the peak at the Yellowknife study area (0.64; Table 6). The opposite scenario was observed for Long-tailed Ducks, where the phenology index at the Yellowknife study areas was high (2.50) and low at the Lynx Lake study area (0.62). While the phenology index was well below 1.00 for the American Green-winged Teal, Mallard and Northern Pintail in Lynx Lake (from 0.12 to 0.54; Table 6), more pairs of Mallard and Northern Pintail were detected in the Yellowknife study area which resulted in phenology indices close to 1 (1.17 and 0.96, respectively; Table 6), suggesting that dabbling ducks were in the peak of nest initiation.

This phenology index was originally developed based on dabbling duck pair behaviour (Bordage et al. 2017), where males defend a breeding territory for the female. Scoter and scaup behaviour may differ as they do not appear to defend territories as aggressively as dabbler ducks. More work is required to develop a phenology index that represents their breeding behaviour accurately.

Table 6. Phenology index (number of detections) by species, site and year, calculated afterward from helicopter surveys.

	Survey sites 2017			Survey sites 2018	
	Little Duck Lake	Lynx Lake	Ramparts	Lynx Lake	Yellowknife
AGWT	0.14 (270)	0.09 (162)	0.73 (256)	0.12 (204)	0.35 (197)
BLSC	0.91 (207)	1.50 (369)		3.67 (374)	2.08 (54)
BUFF	0.43 (32)	0.67 (52)	0.47 (34)	0.61 (36)	0.45 (62)
GRSC	0.93 (58)	0.43 (109)		0.78 (86)	0.56 (24)
HOME	0.36 (146)	1.07 (70)		1.37 (75)	0.29 (71)
LESC	0.97 (155)	0.81 (144)	0.94 (53)	1.05 (195)	0.64 (324)
LTDU	1.04 (63)	0.62 (253)		0.62 (282)	2.50 (62)
MALL	0.48 (135)	0.61 (56)	0.51 (187)	0.37 (84)	1.17 (148)
NOPI	0.40 (107)	0.36 (176)	3.50 (28)	0.54 (239)	0.96 (59)
RBME	1.25 (47)	1.41 (86)		2.15 (93)	1.26 (135)
SCAU	0.45 (82)	0.84 (121)	1.18 (472)	1.63 (77)	0.90 (461)
SUSC	0.89 (144)	0.92 (129)	4.18 (68)	1.31 (251)	0.71 (280)
WWSC	4.50 (57)	3.71 (34)	5.05 (126)	2.71 (70)	4.75(86)

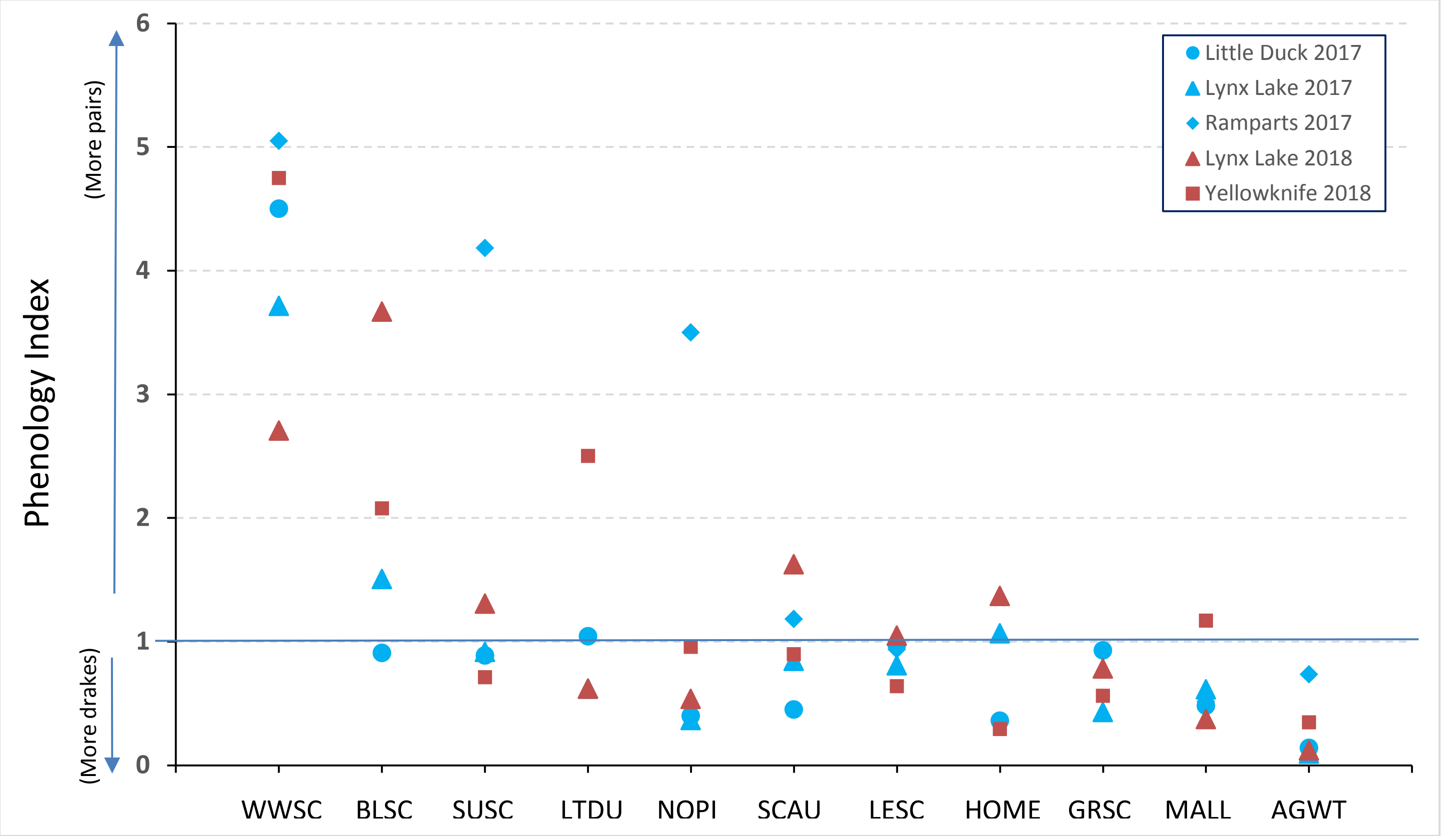


Figure 10. Phenology Index for the most abundant waterfowl species by study area and year in NT and MB, 2017 and 2018.

Surveys

Helicopter Component

We completed surveys of 20, 25 and 26 plots at the Ramparts, Little Duck Lake and Lynx Lake study area from 10-16 June, 21-21 June and 10-21 June 2017, respectively. In 2018, we surveyed 25 plots at each of the Yellowknife and Lynx Lake study areas from 13-20 June and 8-10 June, respectively. All data for 2018 has been transcribed and preliminary summaries have been completed, but the detection analyses have not yet been performed on this data.

Fixed-wing Component

The fixed-wing surveys of both the Yellowknife and Lynx Lake study areas were partially completed in 2018. The most northerly transect in the Lynx Lake study area was not completed because of fuel limitations. The weather was exceptionally poor in the Yellowknife area, leading to delays which prevented some transects to be completed at the site. The transcription of fixed-wing data was completed in September 2018, however analyses of the data have not been completed.

Detection Probabilities

The detection analyses were completed on the 2017 helicopter component but the analyses of detection for the 2018 helicopter and fixed-wing data was not completed at the time this report was prepared. Estimates of detection probability were high for most species, but varied across sites and among observers (Fig. 12 and 13). Detection probabilities for rear observers were consistently greater than for observers seated in the front of the helicopter. We generally assume that visibility is better from the front then the rear of the aircraft and the lower detection likely resulted from the observers carrying out additional tasks (navigation and data recording). In addition, rear observers have a much better view of the rear of the helicopter in the type of helicopter used (Bell 206 LR) and are more likely to detect birds that flush behind the machine. We note that there were slightly different recording methods used by each crew: The Ramparts, Little Duck and Yellowknife crews split the data recording task between the two rear observers, while the Lynx Lake crew had the front observer navigate and record. The double-dependent approach allowed us to assess and correct for the bias introduced by varying detection probabilities across sites.

Total Indicated Pairs

Total Indicated Pairs (TIP) were estimated for all sites and both years (Fig 11). These represent estimates of the number of pairs by plot (i.e. per 25 km^2) uncorrected for incomplete detection. Black Scoters TIP were highest at Lynx Lake and lowest at Ramparts. Surf Scoter TIP was more similar across sites but higher at Little Duck Lake in 2017 and Yellowknife and Lynx Lake in 2018. White-winged Scoters TIP were most abundant at Ramparts. Finally, scaup were the most abundant species at both Ramparts and Yellowknife, with Lesser Scaup accounting for the bulk of the observations at both sites. Long-tailed ducks were had the highest TIP at Lynx Lake. TIP were similar in 2017 and 2018 at Lynx Lake for all primary species, with Surf and White-winged Scoters being higher in 2018.

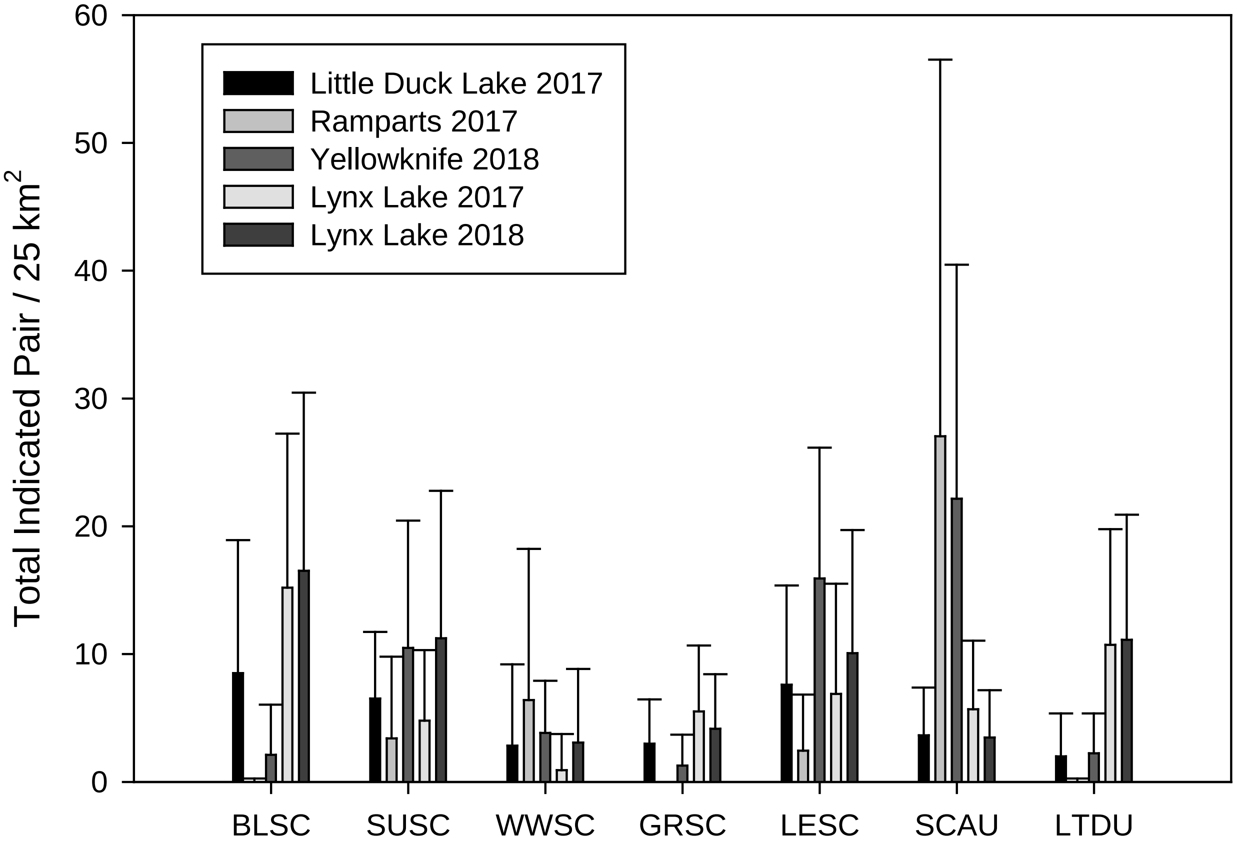


Figure 11. Total Indicated Pairs per 25 km^2 for primary waterfowl species at Little Duck Lake MB, Ramparts NT, Yellowknife NT and Lynx Lake NT in 2017 and 2018. Total Indicated Pairs are uncorrected for detection.

BLSC = Black Scoter; SUSC = Surf Scoter; WWSC = White-winged Scoter; GRSC = Greater Scaup; LESC = Lesser Scaup; SCAU = unidentified Scaup; LTDU = Long-tailed Duck

Density Estimates

Density estimates for breeding scaup and scoter species were very high (Table 7). Our results support our expected distribution of scoter species across Canada, with most White-winged Scoters having been observed in the Ramparts study area (0.57 per km^2, 95% BCI: 0.57 - 0.59) and greater numbers of Black Scoters at the Lynx Lake (1.35 per km^2, 95% BCI: 1.33 - 1.38) and Little Duck sites (0.75 per km^2, 95% BCI: 0.74 - 0.76). Surf Scoter densities were similar across study sites (Table 7). Greater Scaup were most abundant at the Lynx Lake site, with none recorded at the Ramparts site among those birds that were able to be identified to species. However, when all scaup species were combined (i.e. including unidentified scaup), the Ramparts density estimate was almost double that of the two other surveyed sites. Long-tailed Ducks were most abundant at the Lynx Lake site, whereas Common Goldeneye was not observed. This likely relates to habitat differences among sites: Long-tailed Ducks were most often observed on open tundra plots, the habitat type most common at the Lynx Lake site and less common at Little Duck and Ramparts. Likewise, goldeneye require at least some forested cover for nesting, possibly explaining their absence at Lynx Lake and low densities at the two other sites. Mergansers were seen in very low densities at the Ramparts site but moderate densities at Little Duck and Lynx Lake relative to diving ducks, with the exception of Hooded Mergansers at the Little Duck site which were abundant (Table 7). Density estimates are not yet available for 2018.

Contrast to Previous Studies

In comparison with previous studies in other regions of Canada that focused on estimating the abundance of scoter species, the sites surveyed in 2017 and 2018 appear to be used to a greater extent by breeding scoters. Based on uncorrected indicated pair calculations, the four study sites held a larger number of breeding scoters per 25 square kilometers when compared against data collected in Labrador in 2009 and in the Hudson Bay Lowlands of Ontario in 2009 (Brook et al. 2012; Table 8). In particular, Black Scoter TIP were up to 400% greater at Lynx Lake and 200% greater at Little Duck lake than recorded at any other surveyed site, indicating that these sites are within the core breeding range of the species (Table 8). Surf Scoters were also more numerous at Little Duck lake and Lynx Lake than in other comparable studies (Table 8).

Population estimates for the Lynx Lake, Little Duck Lake, Ramparts River, and Labrador study sites are shown in Figure 14 (2018 data not yet analysed for population size). The Lynx Lake site was the largest in area (21,750 km^2) and we projected density estimates from the Little Duck Lake, Ramparts, Yellowknife and Labrador sites to this surface area to allow for a direct comparison among the 5.

Table 7. Mean number of indicated breeding pairs (standard deviation; uncorrected estimate) per surveyed plot (25km^2), predicted probability of detection (lower and upper 95% Bayesian credible interval) and estimated density of ducks per square kilometer (lower and upper 95% Bayesian credible interval) by species for each of the three study sites surveyed in 2017.

Species[†]	**Little Duck Lake**			**Lynx Lake**			**Ramparts**		
	IP / Plot	Detection	Density	IP / Plot	Detection	Density	IP / Plot	Detection	Density
Scoters									
BLSC	8.52	0.937	0.745	14.73	0.810	1.352	0.05	0.685	0.005
	(10.39)	(0.899 - 0.967)	(0.742 - 0.757)	(12.05)	(0.748 - 0.862)	(1.33 - 1.381)	(0.22)	(0.234 - 0.925)	(0.004 - 0.012)
SUSC	6.52	0.909	0.444	5.15	0.870	0.366	3.4	0.702	0.340
	(5.21)	(0.841 - 0.956)	(0.440 - 0.456)	(5.69)	(0.801 - 0.925)	(0.363 - 0.375)	(6.39)	(0.512 - 0.834)	(0.326 - 0.374)
WWSC	2.84	0.944	0.214	1.38	0.838	0.101	6.4	0.824	0.573
	(6.35)	(0.869 - 0.987)	(0.213 - 0.219)	(3.65)	(0.709 - 0.934)	(0.100 - 0.109)	(11.84)	(0.717 - 0.916)	(0.566 - 0.594)
ALL	-	-	1.402	-	-	1.819	-	-	0.917
			(1.395 - 1.419)			(1.798 - 1.849)			(0.896 - 0.956)
Scaup									
GRSC	3.00	0.948	0.183	5.54	0.900	0.385	-	-	-
	(3.45)	(0.877 - 0.987)	(0.182 - 0.188)	(5.05)	(0.830 - 0.953)	(0.383 - 0.394)			
LESC	7.6	0.979	0.592	7.77	0.874	0.507	2.45	0.848	0.269
	(7.77)	(0.947 - 0.996)	(0.592 - 0.597)	(9.59)	(0.808 - 0.927)	(0.503 - 0.518)	(4.38)	(0.717 - 0.956)	(0.266 - 0.282)
SCAU	3.64	0.962	0.317	5.88	0.806	0.467	27.05	0.850	2.262
	(3.74)	(0.913 - 0.991)	(0.317 - 0.323)	(5.36)	(0.715 - 0.880)	(0.458 - 0.486)	(29.46)	(0.802 - 0.890)	(2.244 - 2.292)
ALL	-	-	1.093	-	-	1.358	-	-	2.531
			(1.091 - 1.101)			(1.345 - 1.382)			(0.010 - 0.026)
Mergansers									
COME	0.88	0.937	0.069	2.92	0.792	0.187	-	-	-
	(2.07)	(0.806 - 0.993)	(0.069 - 0.074)	(4.82)	(0.647 - 0.895)	(0.183 - 0.202)			
HOME	4.16	0.917	0.477	1.46	0.823	0.200	0.15	0.636	0.010
	(4.07)	(0.855 - 0.960)	(0.474 - 0.490)	(1.88)	(0.720 - 0.907)	(0.197 - 0.211)	(0.49)	(0.207 - 0.868)	(0.008 - 0.020)
RBME	1.80	0.927	0.146	3.38	0.823	0.245	0.05	0.686	0.003
	(3.49)	(0.841 - 0.979)	(0.146 - 0.152)	(3.29)	(0.716 - 0.908)	(0.242 - 0.257)	(0.22)	(0.236 - 0.922)	(0.002 - 0.008)
Other Seaducks									
COGO	0.80	0.941	0.061	-	-	-	0.25	0.733	0.017
	(1.76)	(0.825 - 0.994)	(0.061 - 0.066)				(0.72)	(0.383 - 0.941)	(0.016 - 0.024)

[†] BLSC = Black Scoter; SUSC = Surf Scoter; WWSC = White-winged Scoter; GRSC = Greater Scaup; LESC = Lesser Scaup; SCAU = unidentified Scaup; COME = Common Merganser; HOME = Hooded Merganser; RBME = Red-breasted Merganser; COGO = Common Goldeneye; LTDU = Long-tailed Duck

LTDU	2.00 (3.35)	0.770 (0.601 - 0.891)	0.165 (0.157 - 0.187)	10.42 (9.00)	0.799 (0.728 - 0.858)	0.665 (0.654 - 0.683)	0.05 (0.22)	0.689 (0.277 - 0.918)	0.003 (0.002 - 0.008)

Figure 12. Predicted detection probability by species for each of the Little Duck Lake, Lynx Lake and Ramparts sites surveyed in 2017. Error bars represent upper and lower 95% Bayesian credible intervals.

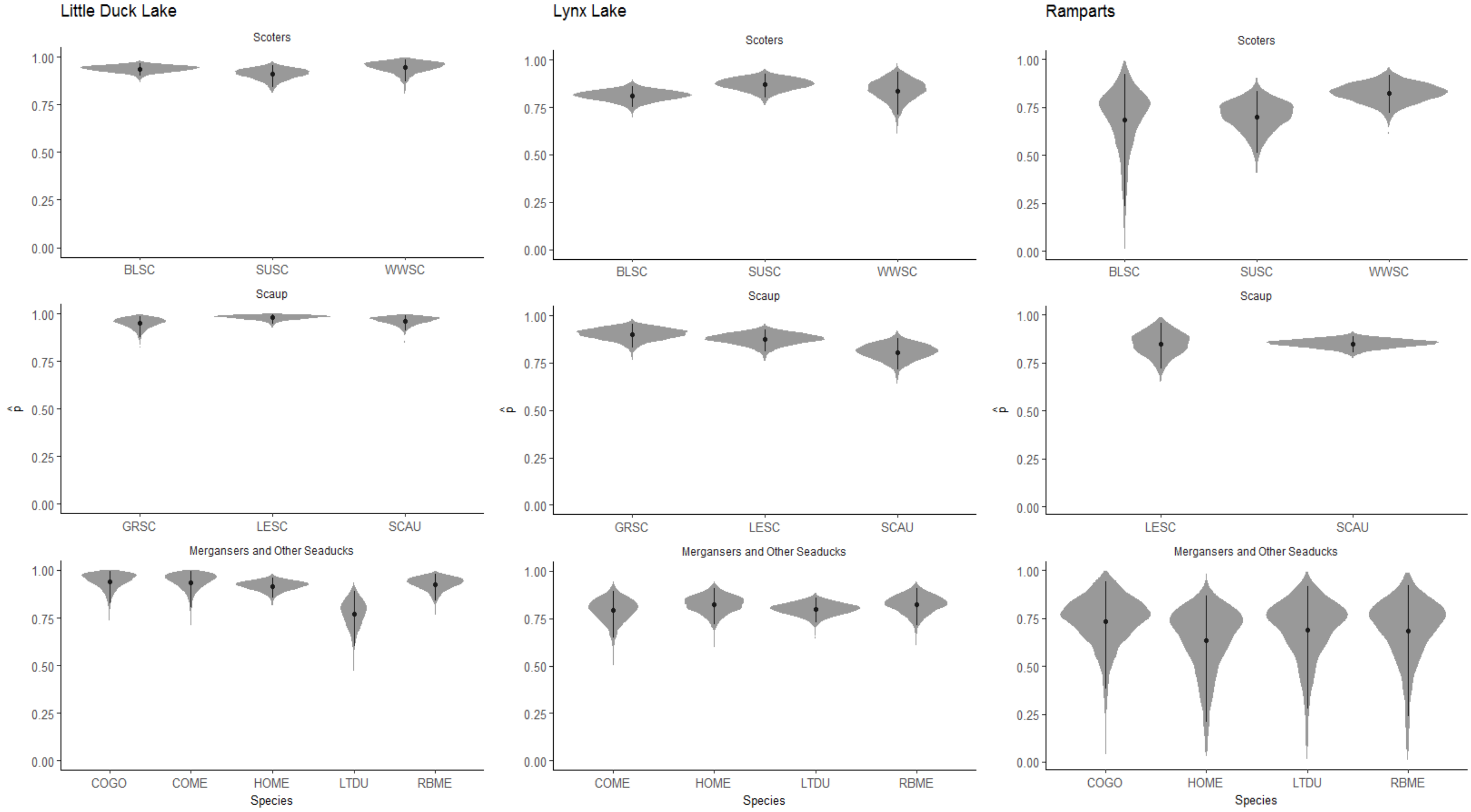


Figure 13. Predicted detection probability by observer and seat position in the helicopter for each of the three sites surveyed in 2017. Error bars represent upper and lower 95% Bayesian credible intervals.

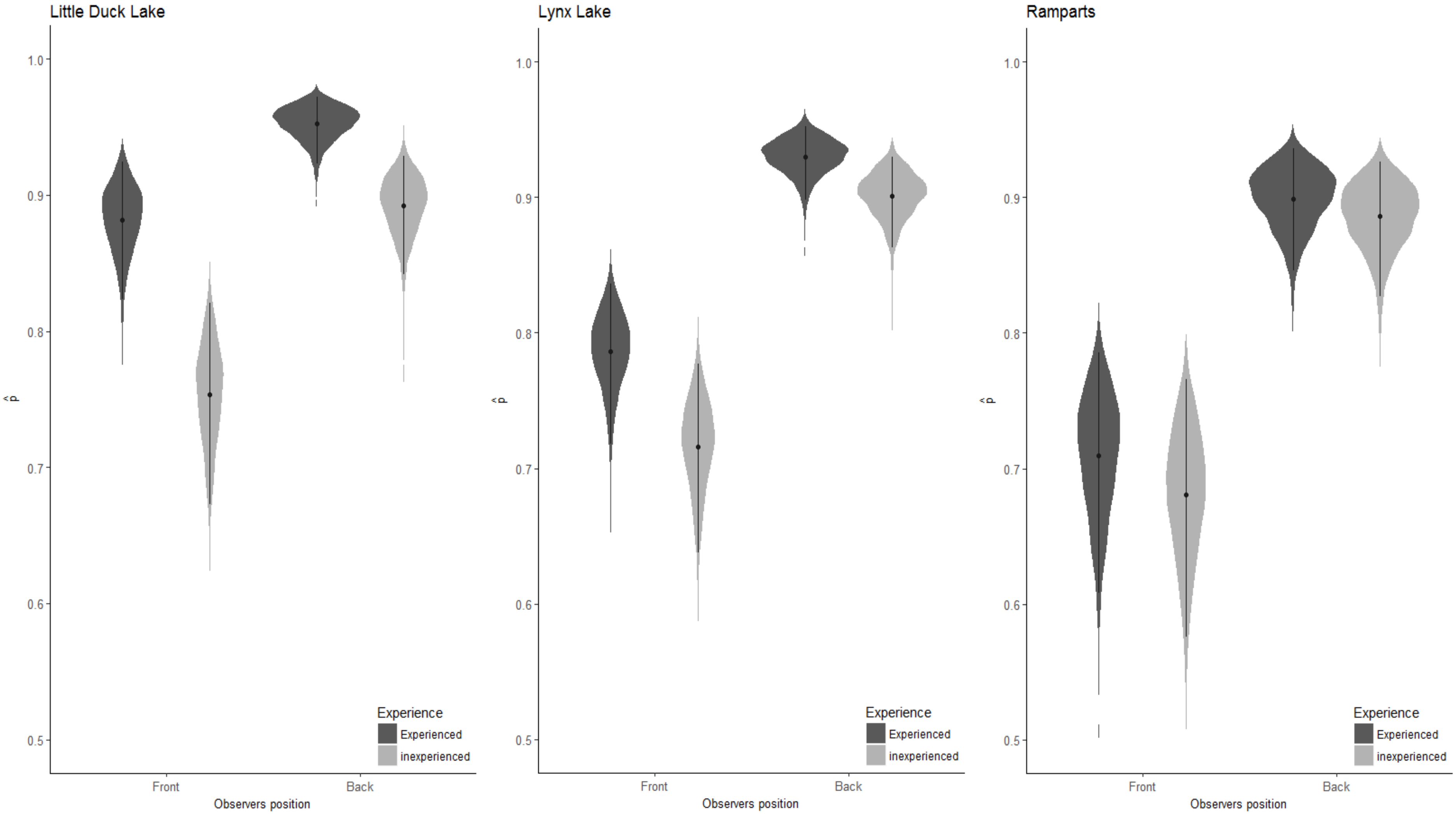
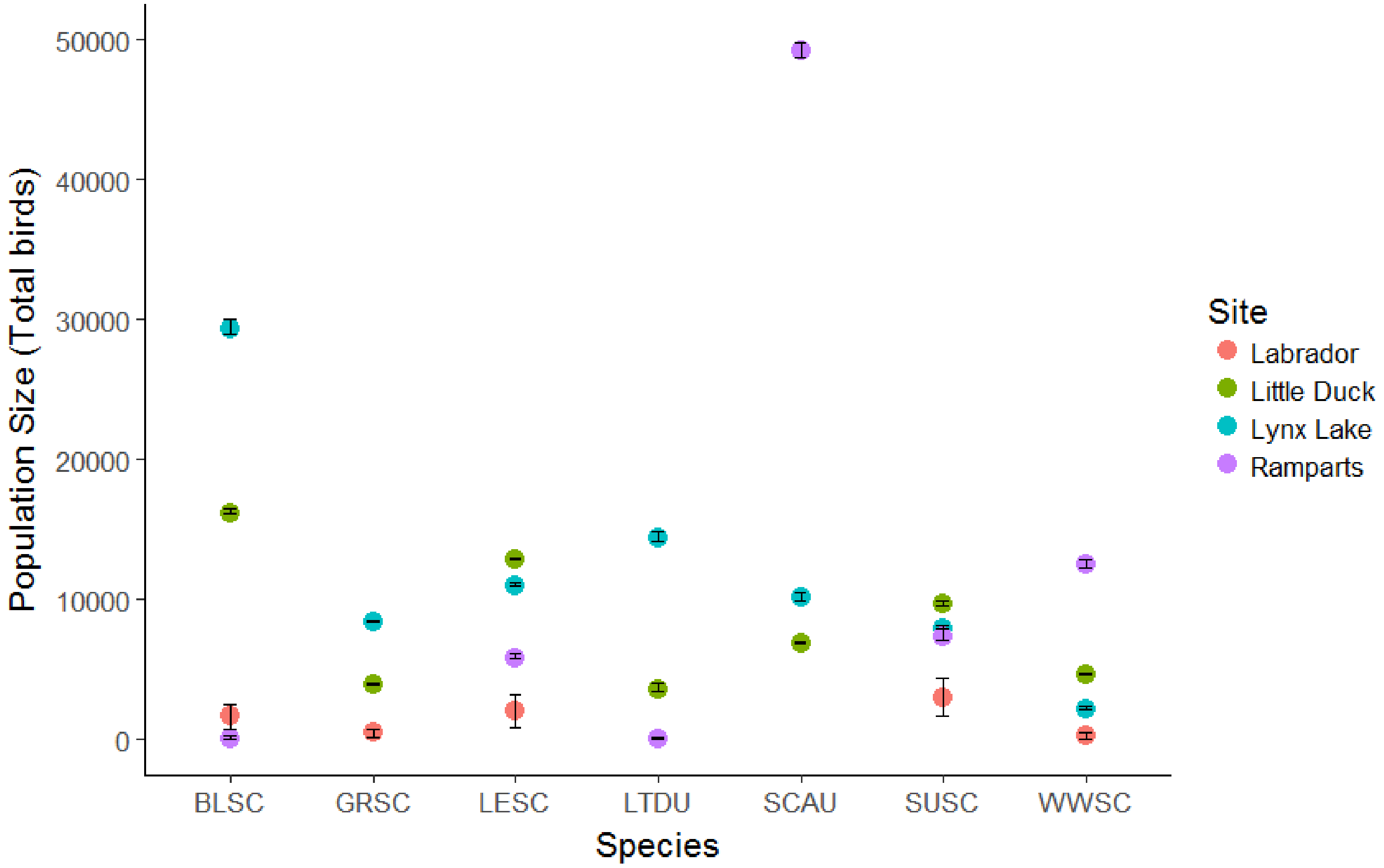


Table 9. Mean number of indicated pairs per 25 km^2 (uncorrected for detection probability) for Black, Surf and White-winged Scoters across the three sites surveyed in 2017 (Little Duck Lake, *n* = 25 plots; Lynx Lake, *n* = 26 plots; Ramparts, *n* = 20 plots). Indicated pair density per 25 km^2 for Labrador (surveyed 2009) were taken from Gilliland et al., report on SDJV Project No. 115 and indicated pairs for the Hudson Bay Lowlands, Ontario (surveyed 2009) were derived from Brook et al. (2012).

Species	**Little Duck Lake**	**Ramparts**	**Lynx Lake 2017**	**Lynx Lake 2018**	**Yellowknife**	**Labrador**	**Hudson Bay Lowlands**
BLSC	8.52	0.05	14.73	16.52	2.12	1.9	4.0
SUSC	6.52	3.4	5.15	11.24	10.48	3.5	2.75
WWSC	2.84	6.4	1.38	3.08	3.84	0.32	1.5

Figure 14. Population size estimates (corrected for detection) for scoters and scaup at Lynx Lake (21,750km^2), Little Duck Lake (projected to a surface area of 21,750km^2), and Ramparts River (projected to a surface area of 21,750km^2 to allow for direct comparison to other sites). Population size estimates for Labrador data (projected to a surface area of 21,750km^2 to allow for direct comparison to other sites) were calculated from the Gilliland et al. report on SDJV Project No. 115.



Project Status

There was a significant delay in the funding from the SDJV. For 2018, we had proposed two study areas: a new study area in the Taïga Shield Ecozone of NT/NU and a repeat of the 2009 study area in Labrador to assess changes in species density over time. We were able to secure additional funds from CWS, but this funding was not enough to cover the costs of two remote sites; however, there was enough funding to cover two sites if we positioned the second site in the Yellowknife area. As the future funding was uncertain, we decided to use the 2017 Lynx Lake study area as a repeat site, and add a second site near Yellowknife.

Sampling intensity objectives were met in 2018, both by the helicopter crews and the fixed-wing crew. Lynx Lake and Yellowknife sites both encompassed a variety of habitats ranging from tundra across the transition boreal forest which resulted in a diverse assemblage of habitats and sea duck species observed across the study areas: all 3 species of scoters, Long-tailed ducks, 3 species of Mergansers, as well as Lesser and Greater Scaup were identified to the species most of the time by the helicopter crews. The Yellowknife site was predominantly boreal forest and had higher densities of scaup than Lynx Lake area. The Yellowknife study area was selected to include habitats not sampled in 2017 and should result in a more robust analysis of habitat selection for all three species of scoters, Long-tailed duck, mergansers and scaup. Survey timing in relation to breeding phenology also appeared to be very good. Surf and Black Scoter densities from this survey are significantly higher than observed in previous surveys conducted in eastern Canada. These results, coupled with information from the Canadian Barrenlands experimental Breeding Survey (SDJV # 141) and from satellite telemetry studies confirm that the Taïga Shield Ecozone of Canada is indeed a core breeding area for those species. Information gathered during the 2017 and the 2018 surveys will be useful in developing future sea duck surveys in the sub-arctic and boreal regions of North America.

2018 data analyses and planning for summer 2019 will be the main activities during fall and winter 2018-19. The 2018 data has been transcribed and compiled and we will initiate the density and detection analyses, as well as the habitat use modelling, for all four study areas surveyed in 2017 and 2018. The comparison between the 2018 results from the helicopter platform and the ones obtained from the fixed-wing platform will also be done. Results from these analyses are expected in January 2019. Planning for 2019, including selection of survey sites and integration of survey platforms, will be based on results from previous surveys (e.g. Labrador survey SDJV # 115, Barrenlands experimental breeding sea duck survey SDJV #141) as well as from the work completed in summer 2017 and 2018.

Funding from the SDJV has now been secured and we plan to collect additional data from helicopter and fixed-wing aircraft to develop better methodologies to integrate data in 2019. More specifically we propose to conduct helicopter and fixed-wing surveys at one or two sites where the breeding ranges of two or more species of scoters overlap: one site will likely be a repeat of the 2009 survey along the Labrador/Québec border. Dependent on funding availability, we will add an additional site that will be located in an area that maximizes the amount of habitat-related information to further refine habitat selection models.

Project Funding Sources (US$). Complete only if funded by SDJV in FY18; this is used to document: 1) how SDJV-appropriated funds are matched, and 2) how much partner resources are going into sea duck work. You may Include approximate dollar value of in-kind contributions in costs. Add rows as needed for additional partners.

SDJV (USFWS) Contribution	Other U.S. federal contributions	U.S. non-federal contributions	Canadian federal contributions	Canadian non-federal contributions	Source of funding (name of agency or organization)
$75,000					SDJV (USFWS)
			$341,500 (includes $119,000 in-kind contribution)		CWS
	$45,000 (includes $15,000 in-kind)				USFWS

Total Expenditures by Category (SDJV plus all partner contributions; US$). Complete only if project was funded by SDJV in FY18; total dollar amounts should match those in previous table.

Activity	BREEDING	MOLTING	MIGRATION	WINTERING	TOTAL
Banding (include only if this was a major element of study)					
Surveys (include only if this was a major element of study)	**$461,500**				**$461,500**
Research					

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Appendix 1. Sources of satellite transmitted data used in determining the arrival and departure dates of scoters tagged in eastern North America.

	Species		
Principal Investigators	BLSC	SUSC	WWSC
S. Gilliland & C. Lepage	40	26	17
P. Loring	3	0	0
M. Perry	12	9	0
P. Wilson	x	0	1
L. Savoy	x	2[1]	16
A. Wells-Berlin	x	12[2]	1
Unidentified	x	4	0

[1] Data from 2 transmitters provided by BOEM project.

[2] Data from 8 transmitters provided by BOEM project.