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Project Title: Aerial Survey Population Monitoring of Polar Bears in Foxe Basin

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Summary

Polar bear population assessment in North America has historically relied on physical mark-recapture. These studies are logistically and financially intensive, and while widely accepted in the scientific community, local Inuit have voiced opposition to wildlife handling. To better reflect Inuit values and provide a rapid tool for monitoring polar bear population size, we developed and implemented an aerial survey in the Foxe Basin subpopulation (FB) during late summer, 2009 and 2010. FB, a seasonally ice-free subpopulation, spans some 1.1 million km^2 in Nunavut. Polar bears concentrate along the coast during late summer, so we delineated survey zones based on proximity to the coastline. We used coastal contour transects, inland transects oriented perpendicular to the coast, and total counts on a sample of small islands and ice floes. We focused effort in the high-density coastal region and designed protocols to enable simultaneous collection of double-observer and distance sampling data from a helicopter. We flew >300 hours and 40,000 km during each year's survey and observed 816 and 1,003 individuals in 2009 and 2010, respectively. In both years, we observed high numbers of bears on islands in northern Foxe Basin and on Southampton Island, neighboring islands and near Lyon Inlet. Encounter rates were highest near the coast, although bears were observed >40 km inland. The shape of the detection function differed substantially between years, likely attributable to observer experience and variable sighting conditions. However, our abundance estimates were highly consistent between years and survey methods, (~2,580 bears (95% CI: about 2,100 - 3,200), and were comparable to an estimate from the early 1990s. Our results suggest that Nunavut's management regime has enabled polar bear abundance in FB to remain relatively stable. Whereas mark–recapture data provide direct estimates of population growth, aerial survey data yield information population on trend only via a time series of population estimates; accordingly, reliance on such data may require more conservative harvest management. The FB aerial surveys provide a framework for future studies during the ice-free

season. Ongoing analysis will evaluate the distribution of bears in Foxe Basin and assess alternatives for long-term monitoring.

Project Objectives

Our objectives were to:

1) Develop and implement an aerial survey to reliably estimate polar bear abundance in Foxe Basin during the late summer, ice-free season.
2) Derive aerial survey-based abundance estimates for the Foxe Basin subpopulation.
3) Assess polar bear distribution in Foxe Basin during the late summer ice-free season, particularly with respect to environmental variables.

Materials and Methods

Study Area

The Foxe Basin subpopulation (FB) is seasonally ice-free, spanning some 1.1 million km^2 across Nunavut and Nunavik in northern Quebec (Figure 1). FB boundaries extend from Hudson Bay and Hudson Strait, northward to central and northern Baffin Island, and westward to the Melville Peninsula and the Fury and Hecla Strait. Seven communities in Nunavut (Cape Dorset, Chesterfield Inlet, Coral Harbour, Hall Beach, Igloolik, Kimmirut, and Repulse Bay) and four communities in Quebec (Akulivik, Ivujivik, Puvirnituq, and Salluit) lie within the FB bounds.

Survey Design and Field Methods

We employed a systematic sampling design to survey FB during the ice free-season. Since polar bears concentrate near the shore during the ice-free season, we divided the study area into the following strata based on proximity to the coastline: high-density coastal zone; moderate-density, within 5 km of the coast; low-density, 5 – 15 km from the coast; and very low-density, 15 – 50 km from the coast. Strata were delineated and the inland extent of the study area defined for the 2009 research season using satellite telemetry data gathered in 2008 – 2009 (Government of Nunavut and University of Alberta, unpublished data). We established an additional stratum for large islands such that transects extended across the entire island. Coats and Mansel Islands in northern Hudson Bay were re-categorized as 'large islands' in 2010.

Sampling included coastal 'contour' transects flown approximately 200 m inland of and parallel to the shoreline in 2009 and at the high water line in 2010, and regularly-spaced inland transects oriented roughly perpendicular to the coastal density gradient (Buckland et al. 2001). Bears along the coast could be sighted from both coastal and perpendicular inland transects that extended to the coastline. Additionally, we conducted counts on a sample of small islands. We attempted to completely survey small, remnant ice floes, and we recorded all bears sighted in the open water.

We concentrated survey effort in the high-density coastal stratum, sampling about 50% of the shoreline across most of FB. However, in a few areas, such as northern Hudson Strait, the highly irregular coastline and logistical constraints precluded sampling along coastal transects. Therefore, these coastal areas were sampled by perpendicular, inland transects alone. Inland transects were systematically spaced at 10 km intervals across FB in both years. We maintained a ratio of 4 : 2 : 1 for transects stretching 5, 15, and 50 km inland, respectively, in 2009. To increase sampling of the far inland stratum, we altered ratios to 3 : 2 : 1 in 2010.

We completed a comprehensive coastal transect and multiple inland transects in the Quebec portion of FB during 2009. This sampling, however, yielded only a single polar bear sighting, presumably due to the early annual recession of ice from the Quebec coastline during the summer. Based on these results, we did not survey Quebec during 2010.

During 2009, significant offshore ice remained near Bowman Bay and in the Fury and Hecla Strait that could not be comprehensively surveyed. We flew randomized transects over ice in these regions and used weekly Canadian Ice Service maps to delineate sea ice extent. These line transect data were incorporated with overland transects and sightings for analysis. Ice and adjacent land were surveyed concurrently to minimize the potential for bears to move between ice and land.

Surveys were conducted from a Bell 206 LongRanger, flown at a groundspeed of about 150 km / hr and an above-ground level altitude of roughly 120 m. Flight parameters were based on pilot work conducted during 2008 (Peacock et al. 2008). Field protocols enabled concurrent collection of both double-observer, or sight-resight (Pollock and Kendall 1987), and distance sampling (Buckland et al. 2001) data. We constructed a partition between the seats to ensure that sightings by the front observers did not cue rear observers. Additionally, observers did not talk to one another until after a sighted bear was completely passed.

Bear locations and flight paths were recorded via GPS and perpendicular distances from sighted bears to transects measured in a GIS (Marques et al. 2006). We remotely assessed sex and age class, documented group size and approximated body condition using a qualitative fatness index (Stirling et al. 2008). We also recorded habitat characteristics and weather conditions (qualitative 1 - 3 scale) that may have influenced detection for each sighting.

Data Analyses

<u>Perpendicular Inland Transects</u>

We used distance sampling to estimate abundance with the inland transect data. Distance sampling relies on the perpendicular distribution of sighted bears from survey transects. A function fit to distance data is used to estimate how bear sighting probability decreases as distance from the aircraft increases. This, in turn, facilitates the estimation of bears that were present but not sighted in the strip. Converting this to density, results are then extrapolated across the study area (by strata) to obtain an estimate of abundance for the entire population.

A fundamental assumption of distance sampling is that all polar bears located on the transect line are detected (Buckland et al. 2001). Failure to meet this assumption results in a negatively biased estimate. Double observer data may be used in a mark-recapture framework to estimate detection on the line (i.e. at distance = 0) and can be integrated with distance sampling to obtain a less biased estimate of abundance (mark-recapture distance sampling, or MRDS; Laake and Borchers 2004). We employed the Huggins mark-recapture model (Huggins 1989, 1991) to evaluate this assumption. The Huggins model is a closed population model in which the likelihood is conditional on capture and facilitates the inclusion of covariates to explain variability in detection probabilities. Front and rear observers comprised our first and second sampling periods, respectively. We fit models including distance as a covariate and allowed detection probabilities and effects of distance on detection to remain constant or vary between front and rear observers. Bears that were completely unavailable to the rear observers (i.e., located directly beneath the aircraft) were treated and coded as removals (i.e., capture history coded as 1. rather than 10 or 11). We conducted this analysis in Program MARK (White and Burnham 1999) and used Aikaike's Information Criteria, adjusted for small sample sizes (AICc) for model selection (Burnham and Anderson 2002).

Following this analysis, we used Program Distance 6.0 (Thomas et al. 2009) to analyze perpendicular inland transect data. Another fundamental assumption of distance sampling is that sampling must be random with respect to the distribution of bears. Because they congregate along the coast, bears sighted from coastal transects may reflect this coastal density gradient. Hence, coastal transects were unable to be analyzed via distance sampling. However, because inland transects extended to the coastline, we were able to include the coastal zone in distance sampling analysis (with the moderate density inland stratum) or separately estimate the number of bears in the coastal zone using contour transects (see below). We created comprehensive and restricted datasets – including and excluding the coastal zone inland transect data, respectively – for both 2009 and 2010. At the most inland extent of inland transects 5, 15 or 50 km from the coast, we flew parallel to the shore to connect to the adjacent transect and return to the coast. We assumed that the density gradient was very slight within the two far inland strata and thus included data collected between consecutive inland transects located entirely within these strata (>1 km from border).

Data were further partitioned into high and low density strata post-survey to improve estimate precision, yielding a total of 8 strata (4 overland transect strata at 2 density levels). Post-survey stratification was based on encounter rates and geographically discrete units (e.g., Southampton and Prince Charles Islands). As mentioned above, a separate ice stratum was additionally included with distance sampling analysis in 2009.

Histograms of sighting distances were initially compiled and illustrated that detection predictably declined with increasing distance from the aircraft for all datasets, suggesting that distance sampling was a suitable method for abundance estimation. Data were right-truncated at 5% to smooth the tail of the detection function (Buckland et al. 2001). We hypothesized that detectability would not vary appreciably by stratum and thus estimated a global detection function. Strata-specific encounter rates and group sizes were used to generate abundance estimates by stratum, and these figures were added to obtain an overall abundance estimate.

We fit conventional distance sampling models using uniform, half-normal and hazard rate key functions and associated series expansion terms. To further examine variability in detection, we fit multiple covariate distance sampling models (Marques and Buckland 2003) using a forward stepwise procedure. We considered weather and habitat covariates in these models. Although covariates were collected on a qualitative 1 to 3 scale, we condensed most into binary categories because of underrepresentation of some values. We initially considered the bear's activity at first sighting (stationary or moving) as a covariate as well. However, activity was likely confounded with sighting distance, since a bear sighted close to the aircraft was more likely to move and to be detected than a bear far from the helicopter (J. Laake, pers. comm.). Therefore, the activity covariate was excluded from final analyses. We used a regression method implemented in Distance to examine whether group size influenced detection and correct for potential size bias in detection (Buckland et al. 2001). Model fit was examined with q-q plots and chi-square, Kolmogorov-Smirnov, and Cramer-von Mises tests, and model selection was based on Akaike's information criteria (AIC) throughout.

We considered individual transects, partitioned by stratum, as sampling units for variance estimation. Planned transects that spanned a single stratum multiple times (e.g., due to crossing an inlet) were pooled by stratum and categorized as a single unit (Aars et al. 2009). Because we estimated a global detection function, the strata-specific abundance estimates were not fully independent of one another. Therefore, the delta method, which is implemented in Distance, is an inappropriate means to estimate the variance of total abundance (Buckland et al. 2001). We used a bootstrapping procedure (1,000 iterations) in which transects were resampled by stratum, a detection function fit to each dataset, and a unique abundance estimate generated to obtain an unbiased estimate of variance (Buckland et al. 2001).

Coastal Contour Transects and Small Islands

To estimate abundance using the coastal contour transects and on small islands, we conducted double observer, or sight-resight, analyses. With sight-resight, a variation of physical mark-recapture, independent teams of observers visually 'mark' (i.e., sight) and 'recapture' (i.e., resight) animals. Independent observers are necessary to estimate individual detection probabilities and the number of bears present in the surveyed area that were not observed by either team. Here, the front (including the pilot) and rear observers comprised the first and second observer teams, respectively. We used the Huggins model to enable the inclusion of covariates to explain heterogeneity in detection probabilities.

We assumed that we effectively sampled 500 m from the flight path along the coast. Because coastal contours were flown 200 m inland of the high water mark in 2009 and along the high water mark in 2010, this yielded a total strip width of land within 700 m and 500 m of the shoreline during the two years, respectively. While this strip width was conservative, high coastal topography in portions of FB (e.g., the eastern coast of Southampton Island) precluded using a broader strip. For small island sampling, we assumed an effective half strip width of 500 m and 750 m in 2009 and 2010, respectively. These strip widths were supported by histograms of inland transect sightings. Additionally, FB's small islands have less topographic relief than larger islands and portions of the mainland.

We implemented the Huggins model in program MARK to estimate detection probabilities with the coastal contours and small island sampling. Discrete groups were treated as the sampling unit, since the detections of individuals in the same group (e.g., adult female and cubs) were not statistically independent. As above, bears that were completely unavailable to the rear observers were coded as removals. Covariates considered in these analyses included group size, activity of the bear at initial detection, weather conditions, and habitat characteristics. We allowed detection probability and weather conditions to vary between front and rear observers, and we assumed the other covariates had a consistent impact on detection.

We initially fit our global models and implemented a backwards stepwise procedure, based on AICc, for selection of covariates. We used the detection probabilities estimated by the most supported model and a generalized Horvitz-Thompson estimator to obtain the number of groups present in the sampled areas. For both the coastal zone and the small island sampling, we extrapolated appropriate density estimates across the study area and extrapolated variance via the delta method (Powell 2007). Estimates were multiplied by mean group size, and we conducted bootstrapping simulations (n=1,000) with observed group sizes and the estimated number of groups to incorporate group size variance.

<u>Total Abundance</u>

We generated two partially independent abundance estimates in both 2009 and 2010. With the comprehensive overland transect dataset, total abundance consisted of separate estimates derived from overland transects extending through the coastal zones, small island sampling, and any bears sighted on small ice floes or in the open water (>1 km from land). The total abundance estimate derived from the restricted dataset also included small island sampling and bears in open water and on small ice floes. In this case, however, the part of the inland transects that intersected the coastal zone were omitted, and coastal contour transects were instead used to estimate the number of bears in the coastal zone; inland transects were used to estimate bears elsewhere. Individual point estimates and their variances were added to obtain four separate abundance estimates. We assigned equal model weights to the estimates (i.e., $w = 0.25$) and used model-averaging to obtain an overall abundance estimate that incorporated process uncertainty and reflected unconditional variance.

Results

We completed the FB aerial surveys during August - September, 2009 and August - October, 2010. We successfully sampled nearly all planned transects in both years (Figure 2), despite particularly challenging weather conditions in 2010. We observed 816 and 1,003 polar bears, including 616 and 790 independent bears, in 2009 and 2010, respectively. Observed litter sizes were similar between years: in 2009, cub of the year (coy) and yearling / 2-year-old litter sizes averaged 1.57 (SD: 0.55, n = 75) and 1.55 (SD: 0.54, n = 53); mean litter sizes were 1.53 (SD: 0.57, n = 80) and 1.40 (SD: 0.50, n=65) for coy and yearlings / 2-year-olds, respectively, in 2010.

The distribution of polar bears was generally consistent between years (Figure 3). High concentrations of bears were observed in central Foxe Basin near Lyon Inlet and on Southampton Island and neighboring Coats, Vansittart, and White Islands and in northern Foxe Basin on Rowley, Koch, Prince Charles, and the Spicer Islands. Relatively few bears were spotted along Hudson Strait and in the Bowman Bay region of western Baffin Island, and sightings were rare near communities. Bears were most frequently observed along coastal contour transects, in the nearshore inland stratum and on large and small islands, but sightings were documented across all strata (Figure 3).

Perpendicular Inland Transects

Large, white polar bears are highly conspicuous against the dark backdrop of land, and our impression in the field was that detection on the transect line was nearly perfect. Preliminary analyses estimated front and rear detection probabilities on and near the transect line at approximately $p = 0.86$ to $p = 0.89$. These individual detection probabilities yielded a combined estimate of detection $(1 – (1 – p)^2)$ of about 98 – 99%, assuming bears were available to be sighted by both sets of observers. We acknowledge, however, that rear observers had a small blind spot directly beneath the helicopter (to a distance of ~70 m from the aircraft), such that a bear located on the transect line during fly-over would be unobservable to the second team of observers. However, bears initially detected by the front observers on or near the transect line sometimes moved off the line and became visible to rear observers. We proceeded with these analyses, considering that detection on the transect line was nearly perfect. We also observed near-perfect detection about 100 m off the line: detection may actually be closer to 1 at this distance than on the line, given the blind spot of rear seat observers. We plan to left-truncate observations within this blind spot (sightings <70 m from the transect line) to ensure that all sightings were available to both teams of observers. All analyses will be completed with the revised dataset, and the two sets of results will be compared and combined.

Our comprehensive and restricted datasets included 193 and 120 groups for distance sampling analysis (before truncation of bears sighted at extreme distances) in 2009 and 317 and 215 groups in 2010. We surveyed nearly 12,400 km of overland transects, allocated among 9 strata, and more than 12,800 km of transects among 8 strata in the two years. All highly supported models (i.e., ΔAICc < 2) indicated adequate model fit by various goodness of fit metrics. Model selection was consistent between comprehensive and restricted datasets within year, and covariate-based models were more strongly supported than conventional distance sampling models across all analyses (Table 1). Additionally, global density estimates were highly consistent among top models within analysis, despite different key functions and covariates, suggesting the robustness of the datasets. We found no evidence for an effect of group size on detection probabilities, so we used strata-specific mean group size in all models.

Estimated detection functions differed significantly between years: a half normal key function was best supported in 2009, while a hazard rate key function was highly supported in 2010 (Table 1). Habitat covariates, however, were included in the top models in both years. The flexibility of the hazard rate function effectively captured the broader shoulder in 2010 (i.e., constant detection to about 800 m). This shoulder, in conjunction with a longer tail in 2010, resulted in a much wider effective half strip width in 2010 versus 2009.

Because of the consistency in global density estimates among our most highly supported models, we selected the top model in each dataset to generate dataset-specific abundance estimates. Abundance estimates were fairly consistent between years for each of the comprehensive (2009: 2401, CV: 11.4%; 2010: 2061, CV: 9.8%) and restricted (2009: 1681, CV: 13.7%; 2010: 1531, CV: 11.1%) datasets.

Coastal Contour Transects and Small Islands

We included 227 and 257 groups in coastal contour transect analyses in 2009 and 2010, respectively. Sight-resight analyses of small islands included 82 and 109 groups in the two years. In all analyses, the best fitting models were parsimonious and included no more than a single covariate to model heterogeneity. Mean estimated detection probabilities for front and rear observers were 0.85 (SE: 0.022; constant detection for front and rear observers) for coastal contours in 2009 and 0.79 (SE: 0.028) and 0.86 (SE: 0.025) in 2010. For small islands, average estimated detection probabilities for front and rear observers were 0.73 (SE: 0.053) and 0.85 (SE: 0.045) in 2009 and 0.88 (SE: 0.026; constant detection for front and rear observers) in 2010. Applying these detection probabilities to our data, multiplying by mean group sizes and extrapolating across FB yielded estimates of 727 (SE: 22.6) and 873 (SE: 23.2) in coastal zones during 2009 and 2010. We estimated an additional 272 (SE: 12.5) bears on small islands in 2009 and 238 (SE: 9.1) in 2010.

Total Abundance

Despite different analytical techniques and detection functions, the four preliminary abundance estimates were remarkably consistent (Table 2). Model averaging yielded a preliminary overall abundance estimate of about 2,580 bears in the Foxe Basin subpopulation, with a 95% lognormal confidence interval of 2,093 to 3,180 (CV: 10.7%).

Discussion and Management Implications

Although aerial surveys are widely implemented to monitor a variety of wildlife species, their application to polar bear subpopulations has been largely limited due to logistical and technical constraints (e.g., Evans et al. 2003 McDonald et al. 1999, Wiig and Derocher 1999). Prior to the FB research, a study conducted over land and on pack ice in the Barents Sea represented the lone, large-scale polar bear aerial survey (Aars et al. 2009). The successful implementation of the land-based aerial survey during the ice-free season in FB thus represents a significant advance in polar bear monitoring techniques. Importantly, the consistency of our results both across years and between the two survey methods suggests that aerial surveys can generate reliable estimates of abundance. Although aerial surveys, like other monitoring techniques, may be subject to bias, consistency in our results and high precision provide promise that aerial surveys can be a useful tool for monitoring trends in FB and other seasonally ice-free subpopulations.

An evaluation of population trend in FB requires a comprehensive analysis of potential sources of bias in the last population estimate, obtained during the 1990s (Taylor et al. 2006), as well as a review of potential biases with the FB aerial surveys. However, a simple comparison of our abundance estimate (N: ~2,580, SE: 278) with that from the early 1990s (N: ~2,200, SE: 260) suggests that FB may have remained relatively stable. This finding implies that the current harvest management regimen has not resulted in a significant change in abundance. Observed litter sizes were generally comparable to those documented in other subpopulations with robust annual growth rates, including Baffin Bay (Taylor et al. 2005), suggesting that recruitment is currently indicative of a healthy subpopulation. Anecdotally, polar bears observed during the aerial surveys generally appeared to be in good body condition (based on a qualitative fatness index; Stirling et al. 2008), further supporting the notion that FB is a healthy subpopulation. The aerial survey results did not provide evidence to suggest that climate change is negatively influencing FB, though impacts have been documented elsewhere in the region (e.g., Western Hudson Bay; Regehr et al. 2007, Stirling et al. 1999).

The Foxe Basin study provides a framework for future aerial surveys in seasonally ice-free populations and serves as a starting point for studies during other seasons or in other ecoregions (Amstrup et al. 2007). While surveys need to be tailored to the unique conditions of a particular region, key design and methodological considerations for land-based studies include:

1) Study area stratification based on proximity to the coast to ensure the efficient allocation of sampling effort and comprehensive coverage of the study site. Information such as satellite telemetry and local knowledge can inform this element of study design.
2) Orientation of transects perpendicular to the coastline (i.e., against the coastal density gradient) to improve precision and reduce bias (Buckland et al 2001).
3) Integration of both double observer and distance sampling field protocols, regardless of the survey platform, study period, or other general design considerations, to facilitate analytical flexibility and evaluate methodological assumptions.
4) Inclusion of independent coastal transects to intensively sample the high-density shore zone, thereby improving estimate precision and minimizing potential bias due to clumpy distribution of polar bears.
5) Collection of covariates that affect sighting probabilities, such as topography, habitat structure, and weather conditions.

Although conducting a comprehensive survey in both 2009 and 2010 required a substantial logistical undertaking and significant financial investment, multiple years of study in FB yielded valuable information about aerial surveys and their application to polar bear subpopulations. For example, despite the consistency documented in our preliminary abundance estimates, we estimated markedly different detection functions during distance sampling analysis. We hypothesize that observer skill and experience, as well as general sighting conditions (i.e., weather conditions not adequately documented and modeled during analysis) likely contributed to this discrepancy. Regardless of the underlying causes, these results indicate that detection functions are not transferrable among subpopulations or between years. In other words, an independent detection function should be estimated for individual surveys. Although distance sampling maintains a pooling robustness property, whereby observations with somewhat different sighting probabilities may be grouped to estimate a single detection function (Buckland et al. 2001), our results encourage biologists to exercise caution when data are to be pooled.

This research additionally establishes a foundation for long-term monitoring in FB, using a method that is rapid and cost-effective in comparison to physical mark-recapture. While a single-year aerial survey requires fewer resources than a multi-year capture-recapture program, we caution that aerial surveys provide trend data only from a series of estimates, whereas mark-recapture data provide direct estimates of population trend (from estimation of vital rates). However, other types of useful data, particularly distribution information, were gained from the aerial survey. We suggest that these data provide a basis for more cost-effective trend monitoring via smaller "index" sites; future study will include assessing the utility of an index to monitor trend. Specifically, the high density areas in FB were geographically consistent from year to year, representing a fraction of the total study area but accounting for roughly 60% of the total abundance. An index, informed by a habitat-based distribution model, may enable managers to monitor population trend by surveying a smaller geographic area. Multiple years of data provide the opportunity to assess whether the index consistently reflects true abundance, a key assumption of any index. Additionally, resampling data will estimate the intensity of sampling required to achieve a target level of precision, and power analyses will enable us to evaluate how reliably an aerial survey will detect specific changes in abundance.

The specific management implications of the FB aerial surveys need to be evaluated by the GN. While the FB study has generated an abundance estimate, the necessity of using the 1990s estimate to assess population trend (instead of current estimates of vital rates) may limit inferences about the current management system. In accordance with the precautionary principle, managing with less information may ultimately require more conservative management and / or more frequent monitoring. However, it seems that the current harvest management regime has allowed FB to remain relatively stable since the early 1990s.

As mentioned above, additional distance sampling analyses with a revised (left-truncated) dataset will be presented in the final project report to the GN. Additionally, the GN report will be peer-reviewed, and we are preparing a manuscript for publication in a peer-reviewed journal. Therefore, we anticipate that there may be modest changes to the results reported here. The final report to the GN will be provided to the NWMB as an addendum and may include more specific management recommendations and technical discussion.

Evaluating the distribution of polar bears during the ice-free season in relation to environmental, ecological, and anthropogenic drivers was a secondary objective of this project. Distributional data obtained during the FB aerial surveys will be pooled with the recent Western Hudson Bay subpopulation aerial survey (Government of Nunavut and University of Minnesota, unpublished data) to facilitate a more comprehensive analysis of late summer distribution in the Hudson Bay complex. We anticipate that this analysis will be completed in mid-2012, and results will be distributed to the GN, NWMB, local communities, and other stakeholders.

Community Reporting

The following table outlines the schedule of consultations and reporting associated with the Foxe Basin aerial survey. Final project reports will be distributed to communities and consultations conducted during late winter to early spring, 2012.

Meeting or Action	Date
Consultations: All communities within Foxe Basin boundaries (Cape Dorset, Chesterfield Inlet, Coral Harbour, Hall Beach, Igloolik, Kimmirut and Repulse Bay), Rankin Inlet, KIA, and Ukkusiksalik NP. Written reports sent to Baker Lake.	Spring 2006 - Winter 2008
Distribution of written interim reports (2008 research season) to all stakeholders.	January 2009

Consultations in all FB communities.	Winter – Spring 2009
Distribution of written interim reports (2009 research season) to all stakeholders.	January 2010
Interim community consultations and informal reporting with HTO representatives.	Late summer, 2010
Interim written reports distributed to all stakeholders.	January 2011
Final project reports, management recommendations, and community consultations.	Winter 2011 – Spring 2012

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Figure 1. The FB polar bear subpopulation spans more than 1 million km^2 in Nunavut and northern Quebec. Multiple strata were delineated for the FB aerial surveys.

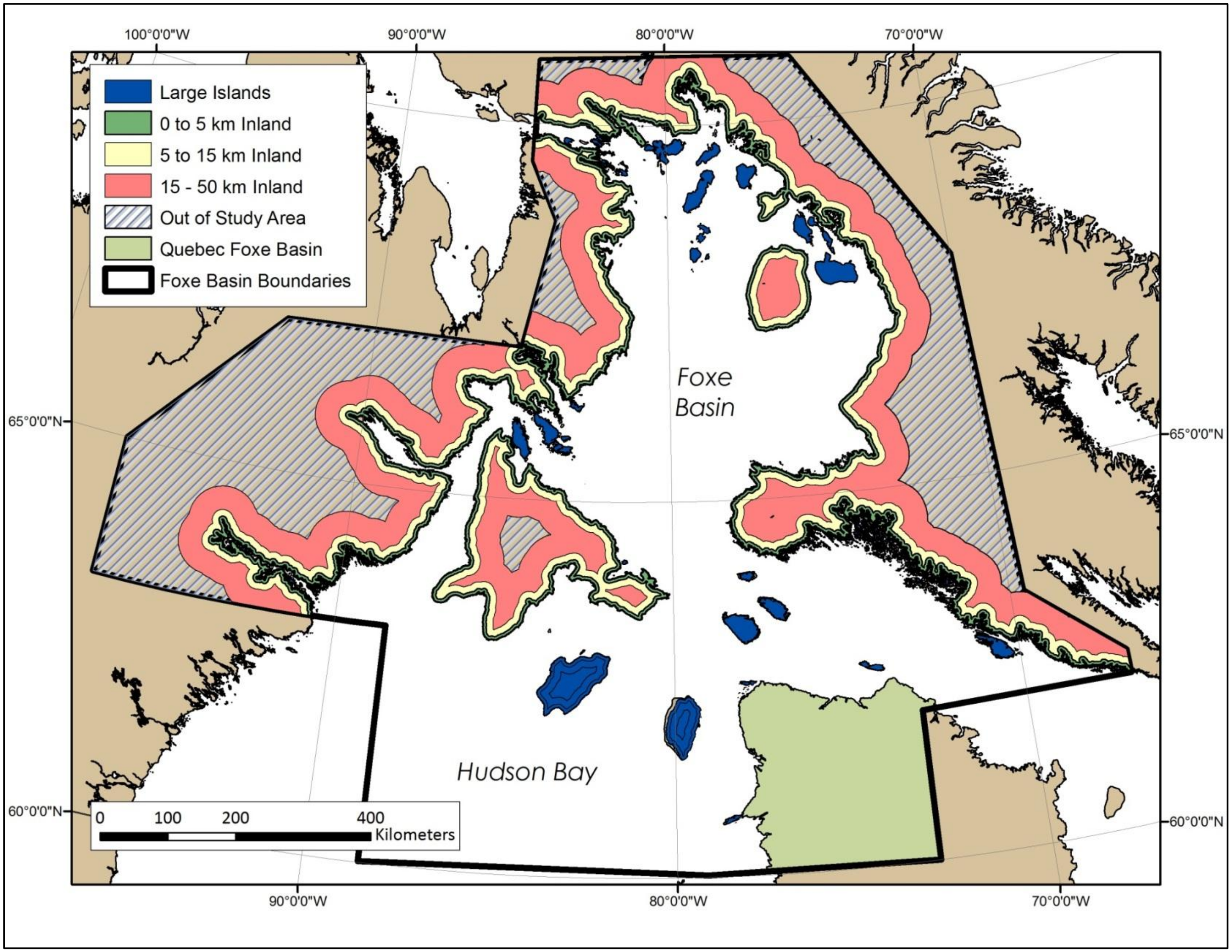


Figure 2. Transects flown during the Foxe Basin polar bear subpopulation aerial survey, August to October, 2010.

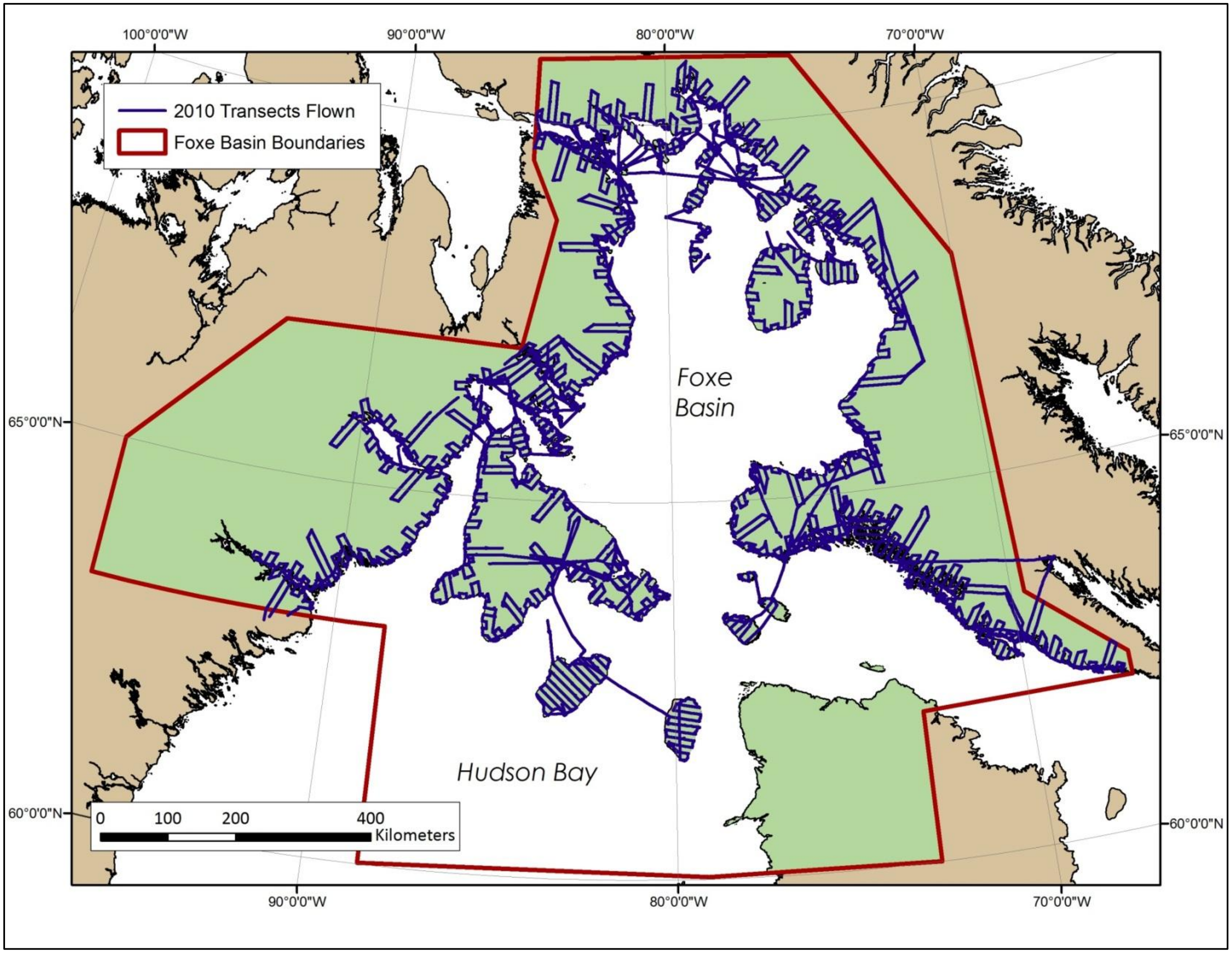
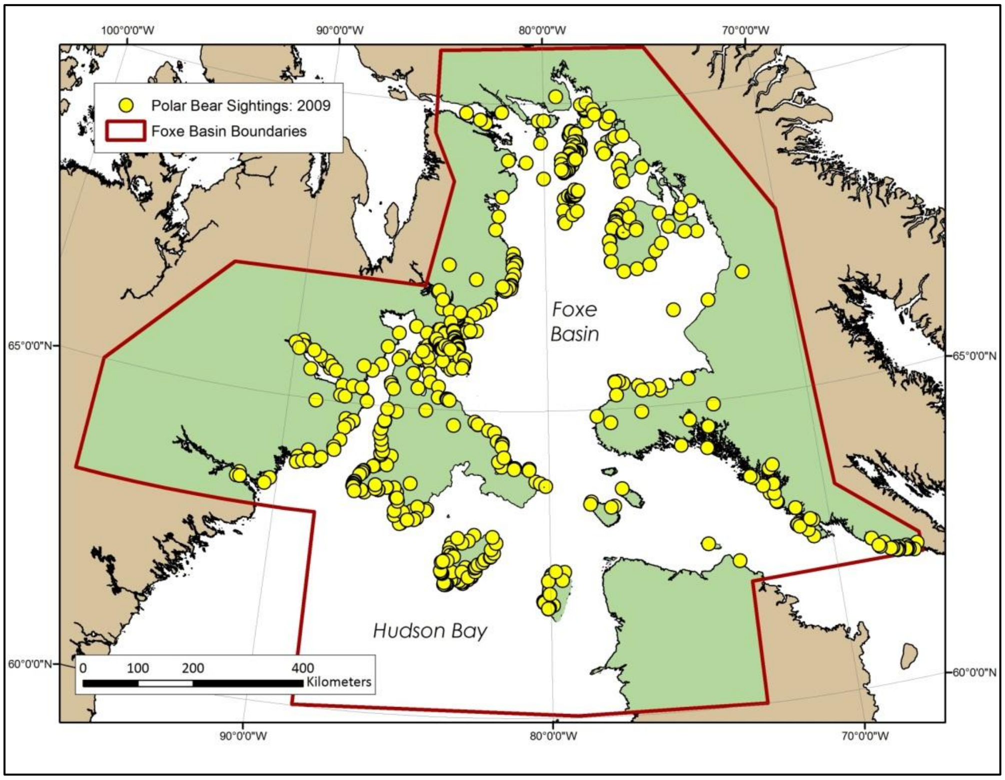


Figure 3. Distribution of polar bears observed during the Foxe Basin aerial surveys.

(a) 2009



(b) 2010

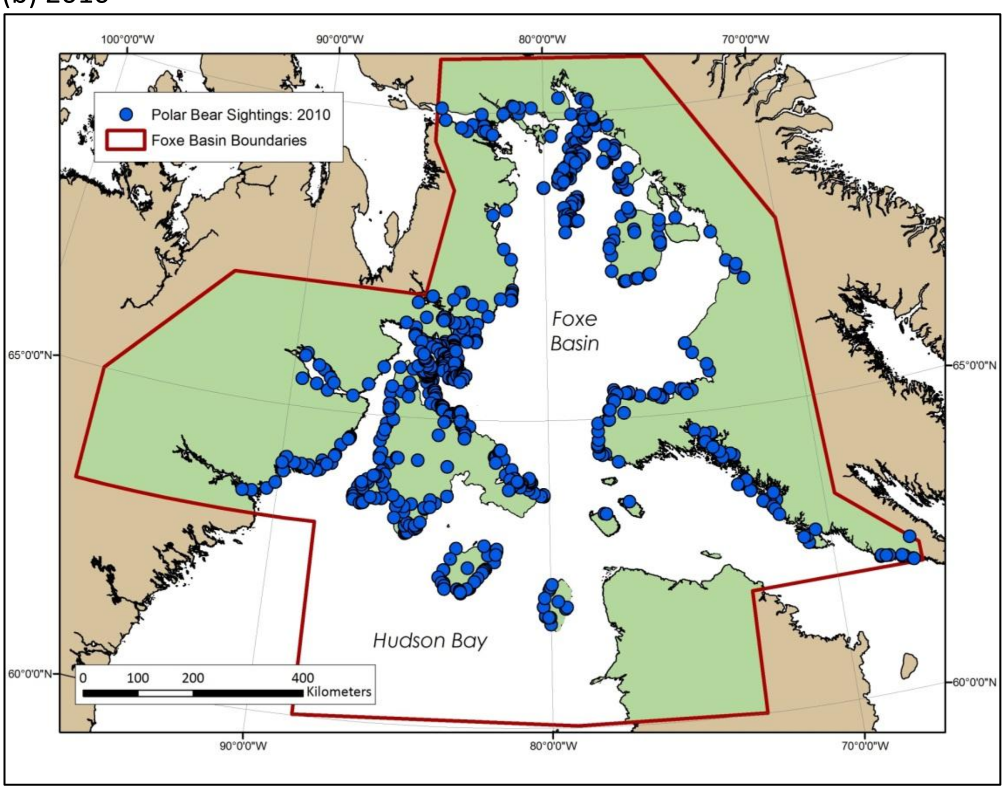
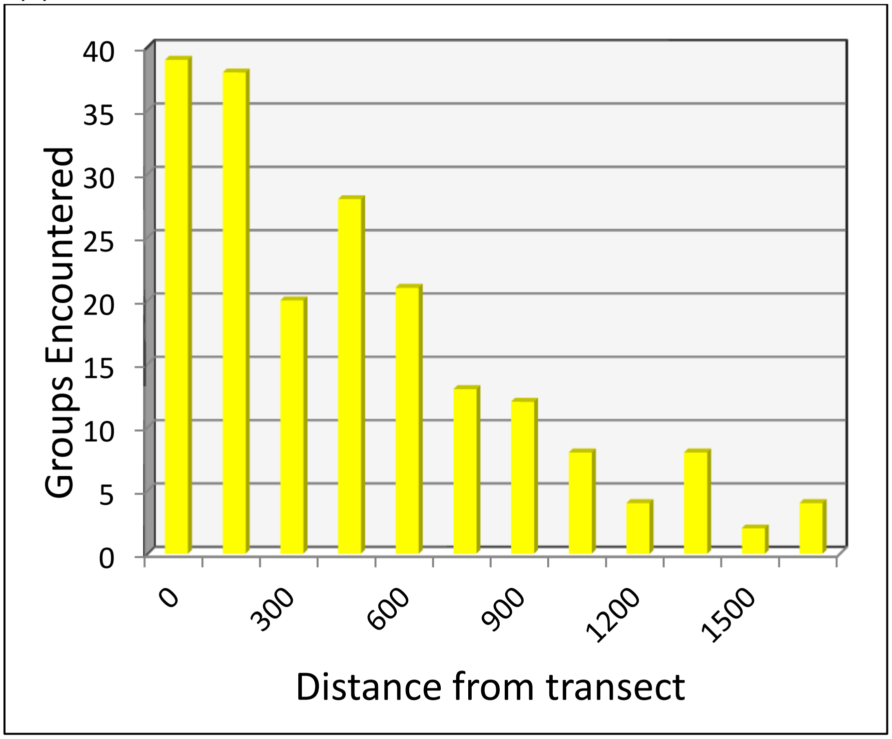


Figure 4. Histograms constructed with the comprehensive datasets in 2009 and 2010, showing the distribution of sightings from the transect line. All strata are pooled.

(a) 2009



(b) 2010

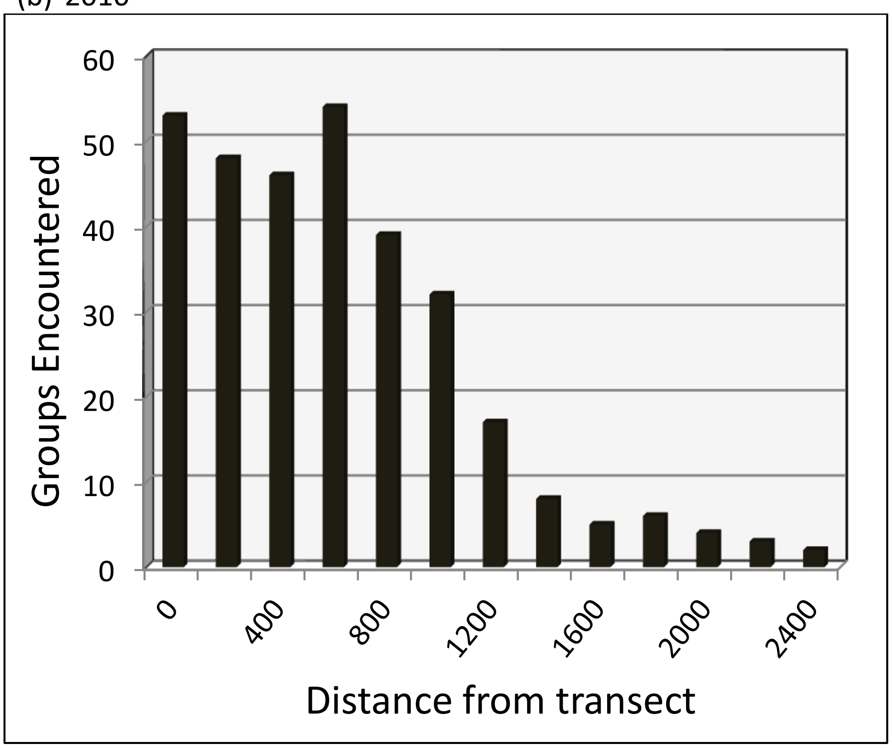


Table 1. Summary of most supported models (ΔAIC < 2) for distance sampling analyses of Foxe Basin polar bear aerial surveys conducted during 2009 and 2010. In the column *Model*, the first term signifies the key function and subsequent terms represent covariates (Habitat = General habitat conditions; Topo = topographic relief; Struc = Habitat structure within a 30 m radius of the polar bear; Vis = visibility).

Dataset	**Model**	**ΔAIC**	**Parameters**	**ESW (m)**	**Global Density (bears per km^2)**	**95% CI**
2009: Comprehensive						
	Half-normal + Habitat + Vis	0.00	3	764	0.008	0.007 – 0.010
	Half-normal + Habitat	0.04	2	780	0.008	0.006 – 0.010
2009: Restricted						
	Half-Normal + Habitat	0.00	2	795	0.006	0.005 – 0.008
	Half-normal + Habitat + Vis	0.34	3	786	0.006	0.005 – 0.008
2010: Comprehensive						
	Hazard + Topo	0.00	3	1193	0.007	0.006 – 0.008
	Hazard + Topo + Vis	1.86	4	1186	0.007	0.006 – 0.008
2010: Restricted						
	Hazard + Topo	0.00	3	1207	0.005	0.004 – 0.007
	Hazard	1.63	2	1196	0.005	0.004 – 0.007
	Hazard + Topo + Struc	1.97	4	1205	0.005	0.004 – 0.007