SUPPLEMENTARY MATERIAL 2 TO THE WESTERN HUDSON BAY POLAR BEAR AERIAL SURVEY REPORT : ANALYSIS OF TREND

Methods

Trend was estimated using results of the distance sampling surveys in 2011 and 2016 as well as counts of bears during coastal surveys that occurred in August from 2011 to 2016.

Coastal surveys

Coastal surveys were conducted along the coast line of the high and moderate south survey strata to the Ontario-Manitoba border from 2011 to 2016 by the government of Manitoba as well as years preceding 2011. We analyzed this survey data to allow another trend estimate for comparison with trend based on the ratio of the 2011 and 2016 survey estimates. Of additional interest was whether trend in adult males which display higher movements and home range areas was similar to adult females with dependent offspring and subadults that potentially display lower movement patterns. Therefore, we analysis was stratified by these classes to assess similarity of trends. Log-linear models (McCullough and Nelder 1989, Thomas 1996) were used for trend analysis. More exactly, a generalized linear model with a quasi-Poisson distribution of counts was used with an exponential link term. The exponent of the slope term from this model provided an estimate of annual rate of change (λ). Analyses were conducted for adult males, adult females with dependent offspring (and lone females), subadult/unknown bears, and pooled classes. Emphasis was placed on the adult male and adult female with offspring classes since these groups could be classified with highest certainty.

Distance sampling surveys

Model averaged estimates from 2011 and 2016 for pooled sex classes were compared using t-tests. Population rate of change was also estimated as the 5th root of the ratio of the 2011 and 2016 estimate. Of added interest was whether there were trends in age and sex class as indicated by an adult male class and adult female (lone and with dependant offspring) class. Estimates for these 2 classes were obtained by first classifying each group encountered as an adult male class, adult female/offspring, and subadult/unknown class or a mixed class if both adult males and females/offspring and subadult/unknown bears occurred in the group. The data was then post-stratified by these classes and estimates were derived from the most supported distance sampling (2011) or distance sampling-mark-recapture model (2016). Group-specific estimates were then extracted from the mixed groups by multiplying the estimate by the proportion of each class in the mixed group. Estimates for each group from the mixed groups were then added to the respective adult male or adult female/offspring/subadult category. Variances were estimated using the delta method (Buckland et al. 1993).

Results

Summary of counts

Counts of polar bear age and sex groups from coastal and distance sampling (coastal and inland) surveys are summarized in Figure SM2.1 which suggest a large degree of variability in the adult male class compared to other classes. For example, the adult male class seems to increase with year for both coastal and distance samples whereas the other classes appear to be stable. A different classification scheme was used for coastal counts in 2011 which resulted in less age and sex classes. This year was used in the overall trend analysis but was not used in the age-class specific trend analysis due to the different classification scheme. The higher count of bears in the 2016 distance survey was due to better survey conditions as discussed previously in Supplemental Material 1. However, the increase in counts appears to be due mainly to an increase in counts of adult males compared to other age-sex classes. There were roughly equal numbers of unknown bears in coastal surveys from 2012-6 and roughly equal numbers of subadults/unknown bears in the 2011 and 2016 distance sampling surveys.

Trend analysis of coastal surveys

Log-linear model results suggest significant negative trends for the female/subadult class and positive but non-significant positive trends for the male and pooled classes (Table SM2.1).

Plots of log-linear model predictions suggest reasonable fit with most counts contained within confidence limits (Figure SM2.2).

Distance sampling surveys

Comparison of model averaged estimates of abundance for 2011 (949 bears , SE=168.9, CI=618-1280, CV=17.7%) and 2016 (842 bears SE=142.6, CV=16.9%,CI-562-1121) using t-tests suggested the difference between the 2 estimates was not significant (t=0.48, df=452,p=0.63). The ratio of the 2 estimates resulted in a gross change of 0.89 which translates to an annual change (λ) of 0.98 (CI=0.89-1.08).

We note that another estimate of abundance of 1030 that combined coastal surveys and inland samples was produced for the 2011 data set (Stapleton et al. 2014). Coastal surveys were not conducted in unison with distance sampling in 2016 and therefore this type of estimate could not be derived for 2016. Therefore, the most comparable estimates in terms of assessing trends are the distance sampling only estimates from the two years which used similar methodologies. We note that the 2011 estimate of 1030 (CI=754–1406) and the 2016 are not significantly different (t=0.87, df=454, p=0.39).

Post-stratified estimates of adult male and adult female/offspring/subadult classes were derived from the most supported models for 2011 and 2016. In all years the majority of bears were contained within segregated “pure” groups with few bears in mixed groups (Table SM2.2). For example, in 2011 there were 5 groups with adult males and adult females/offspring or subadults/unknown. These groups contained 13 bears of which 4 were adult males, 6 were adult females and 3 were subadults/unknown. Subadult/unknown class bears comprised 19% and 13% of the abundance estimate in 2011 and 2016 respectively.

A comparison of pooled and post-stratified age class estimates reveals a decrease, as with the coastal surveys, of the adult female and offspring class, an increase in the adult male class and a decrease in the pooled estimate (Figure SM2.3). None of the differences were statistically significant at α=0.05).

Estimates of annual trend (λ) from coastal and distance sampling surveys reveal roughly similar trends for age-sex groups with declining adult female & offspring classes and an increasing adult male class.   The pooled estimate of trend for coastal surveys suggest increasing abundance whereas the distance sampling estimate suggests decreasing abundance, however, both estimates of trend are not significant with estimates overlapping 1 (Figure SM2.4).

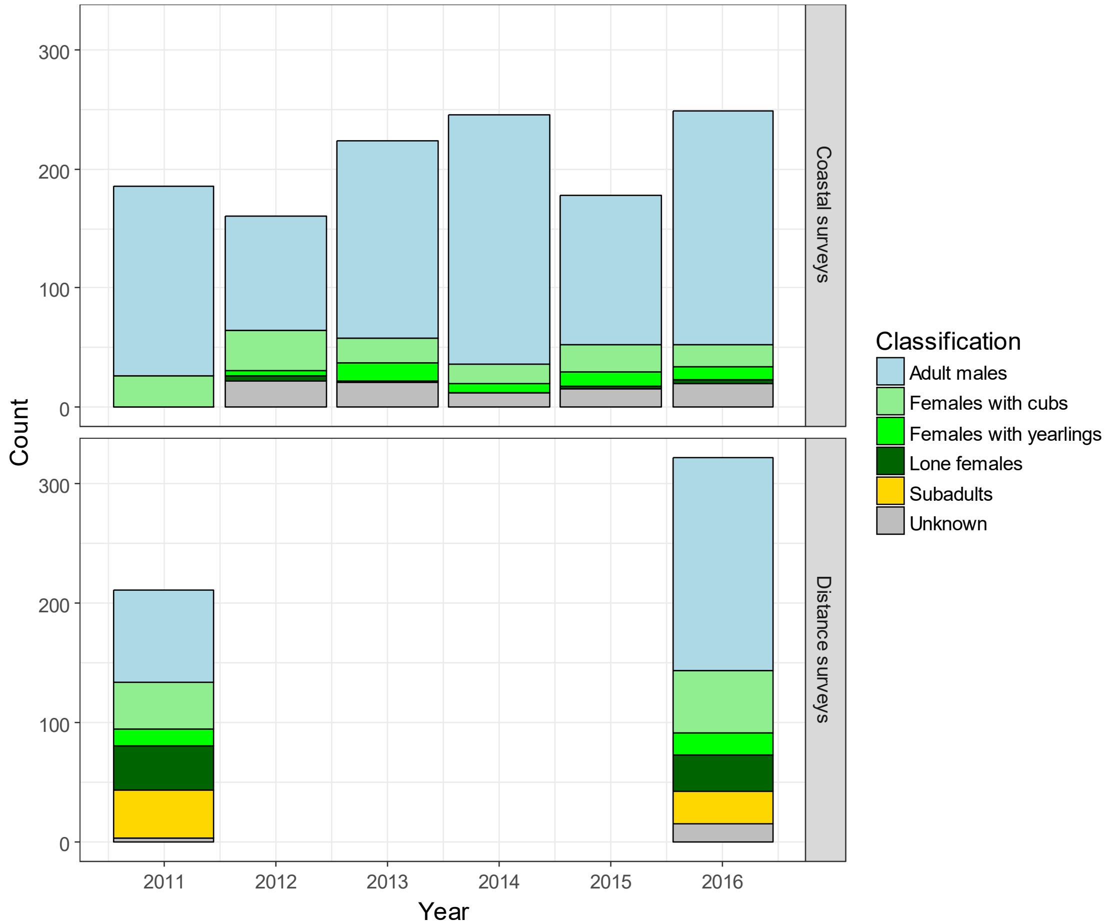

Figure SM2.1: Counts of sex and age-classes by coastal and distance sampling surveys. The counts from the distance sampling surveys only include on transect observations to ensure comparability with estimates of abundance from surveys.

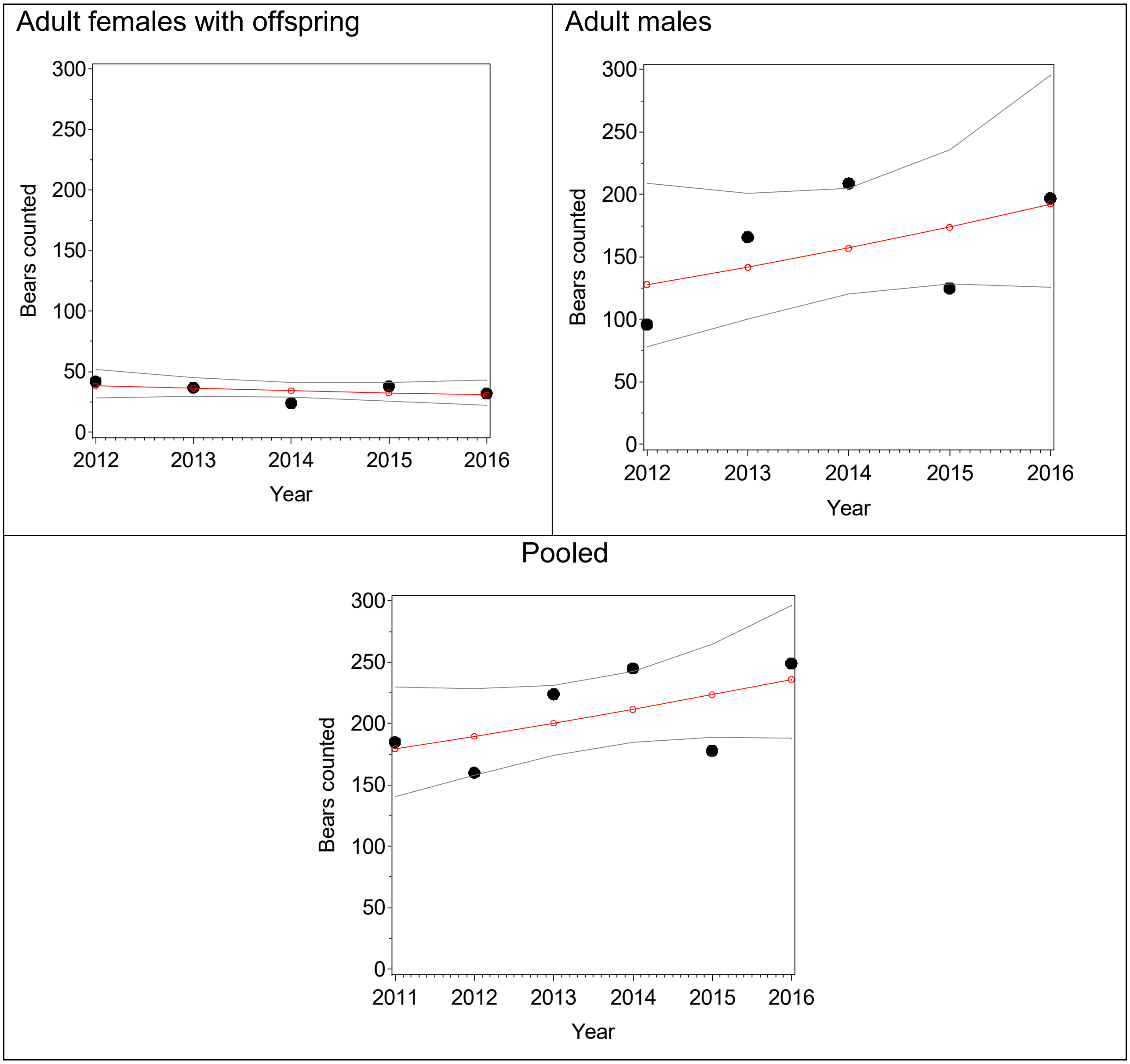

Figure SM2.2: Predicted trend from log-linear models of coastal survey. Counts are given as black dots with model predictions as red lines with associated confidence limits.

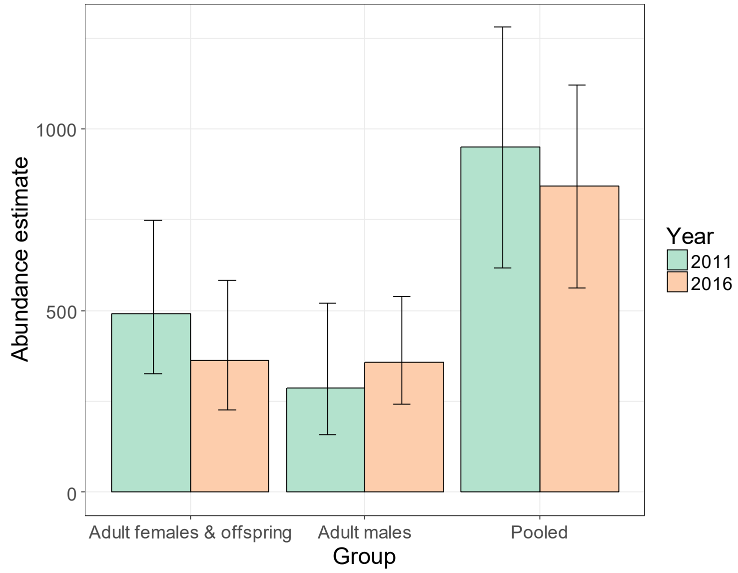

Figure SM2.3: A comparison of model average pooled estimates and sex/age group post stratified estimates for 2011 and 2016.

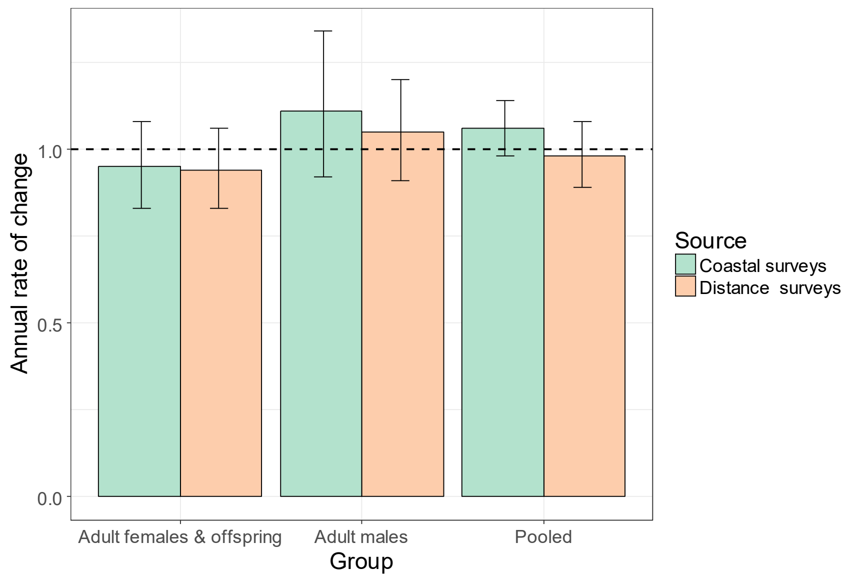

Figure SM2.4: Comparison of annual trend from counts of bears on coastal surveys (2011-6) and distance sampling survey estimates (2011 and 2016). An annual rate of change estimate of 1 that indicates population stability is shown as a dashed line.

Table SM2.1: Estimates of trend from log-linear models for the adult female/offspring/subadult, adult males, and pooled groups for the Hudson Bay coastal surveys. The slope term (β) which is an estimate of *r* (the intrinsic rate of increase) is given with confidence limits and significance tests. Estimates of λ are derived as the exponent of β slope term.

Group	**Log-linear model results**						**Trend (λ) estimate**		
	β	SE(β)	Conf. Limit		χ^2	p	λ	Conf. Limit	
Adult females & offspring (2012-6)	-0.06	0.07	-0.18	0.07	0.70	0.401	0.95	0.83	1.08
Adult males (2012-6)	0.10	0.10	-0.09	0.29	1.13	0.288	1.11	0.92	1.34
Pooled (2011-6)	0.05	0.04	-0.02	0.13	1.88	0.170	1.06	0.98	1.14

Table SM2.2: Post-stratified estimates of age and sex groups for the 2011 and 2016 distance sampling surveys

year	group	groups	Bears counted	N	SE	Conf. Limit		N CV
Adult females/offspring								
2011	Pure	54	88	484	101.4	321	728	21.0%
	Mixed	4	6	8	4.1	3	21	49.5%
	total	58	94	492	101.5	325	749	20.6%
2016	Pure	69	118	355	84.5	223	564	23.8%
	Mixed	8	5	9	3.7	4	20	41.1%
	total	77	123	364	84.5	227	583	23.3%
Adult males								
2011	Pure	53	76	280	84.9	155	505	30.4%
	Mixed	5	4	6	2.7	2	14	49.5%
	total	58	80	285	85.0	157	519	29.8%
2016	Pure	71	163	324	60.0	226	466	18.5%
	Mixed	8	18	32	13.2	15	71	41.1%
		79	181	357	61.4	241	537	17.2%
Subadults/unknown								
2011	Pure	35	40	173	40.2	110	273	23.2%
	Mixed	5	3	4	2.0	2	10	49.5%
	total	40	43	178	40.2	112	283	22.6%
2016	Pure	24	27	96	29.3	53	174	30.4%
	Mixed	8	8	14	5.9	7	32	41.1%
	total	32	35	111	29.9	60	205	27.0%