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Demography and Behavior of Polar Bears Summering on Shore in Alaska (USFWS)

US Department of the Interior
Bureau of Ocean Energy Management
Alaska OCS Region

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Eric Regehr, U.S. Fish and Wildlife Service

A young polar bear on shore in the Southern Beaufort Sea, autumn 2010

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1.0 EXECUTIVE SUMMARY

Global climate change is anticipated to significantly alter habitat and lead to shifts in species' distributions, which can result in increased levels of human-wildlife conflict. Polar bears (*Ursus maritimus*) in northern Alaska are increasingly using onshore habitat during summer and autumn due to sea ice loss, leading to higher incidents of conflict and concerns for human safety. We sought to understand the relative influence of sea ice conditions, habitat characteristics, and human activities on the distribution and abundance of polar bears while onshore. Based on 15 years (2000-2014) of aerial survey data, we built a Bayesian state-space model to estimate the weekly (late August to late October) number and distribution of polar bears onshore in northern Alaska, as a function of sea ice conditions, onshore habitat, and subsistence whaling activities. We then used the model results to evaluate how management of subsistence-harvested whale remains in Kaktovik, Alaska, affected the number of polar bears adjacent to the community. The weekly number of bears onshore was strongly related to sea ice conditions, with more bears onshore when ice was further from the coastline and when ice extent was reduced over the continental shelf. The distribution of bears on shore was most strongly affected by the date of sea ice retreat and the presence of whale carcasses, with more bears occurring in areas with earlier ice retreat dates and a whale carcass. Our findings suggest that potential management strategies for moving or disposing whale carcasses could reduce the estimated number of bears adjacent to the community of Kaktovik by approximately 70%. Our results highlight a potential strategy for reducing human-bear conflict in the region, while accounting for environmental factors that also influence the distribution and number of bears. Our approach can serve as a template for others attempting to find management solutions to increased human-wildlife conflict associated with changing habitat and species distribution.

2.0 BACKGROUND

This Final Report describes activities and findings under Intra-Agency Agreement (IAA) M09PG00024 between the Bureau of Ocean Energy Management (BOEM) and the U.S. Fish and Wildlife Service (USFWS). The goal of this IAA was to study patterns and consequences of land use by polar bears (*Ursus maritimus*) in the Southern Beaufort Sea and adjacent regions of the Chukchi Sea, and to develop strategies to reduce the negative consequences of the interaction of polar bears and human activities in the region. The specific objectives of the IAA were:

1) Estimate the polar bear abundance on Alaska's north coast during the open-water season from mark-resight and radiotelemetry;
2) Evaluate the performance of new satellite telemetry tags; and
3) Develop strategies to reduce the possibility that industrial development and changing environmental conditions will interact to the detriment of the polar bear population.

These objectives were formulated in conjunction with planned field efforts under a second IAA, M09PG00025 "Demography and Behavior of Polar Bears Summering on Shore in Alaska (USGS-BRD)", developed between BOEM and the U.S. Geological Survey (USGS). During the period of performance 2009-2016, field methods for both IAAs were modified based on a joint decision between USFWS, USGS, and BOEM to stop physically capturing polar bears on shore during the autumn, and rather to implement less-invasive sampling methods including aerial counts, line-transect distance sampling, and collection of genetic material via biopsy darting. Working with the BOEM Contracting Officer's Representative (COR), USFWS identified methods to meet the objectives under IAA M09PG00024 without use of data from physical captures. Objective 1) was met by conducting annual aerial surveys of the Southern Beaufort Sea (SB) polar bear subpopulation in the autumn when some bears are concentrated along the coast, and analyzing the data in a customized state-space model developed in Bayesian framework, as described in the main text of this Final Report and an associated publication in the peer-reviewed scientific literature (Wilson et al. 2017). Objective 2) was met by developing and deploying prototype ear-mounted and glue-on satellite radio tags during physical-capture research led by USFWS on the adjacent Chukchi Sea (CS) subpopulation of polar bears (Appendix I). Critical steps were taken toward meeting objective 3) by creating an improved database for the Letter of Authorization Reporting System (LOARS), which contains reports of polar bear observations and human-bear interactions on the North Slope of Alaska as submitted to USFWS to meet requirements of the MMPA (Appendix II). Finally, support under this IAA was used to expand sampling for physical-capture research of the CS subpopulation to areas north of the Lisburne Peninsula, to provide updated information on delineation of the SB and CS subpopulations as necessary to identify potential impacts of human activities in the Chukchi Sea Planning Area (CSPA) for oil and gas activities (Appendix III). Scientific findings supported by this IAA are important to the management and conservation of polar bears under the U.S. Endangered Species Act (ESA), U.S. Marine Mammals Protection Act (MMPA), and National Environmental Policy Act.

3.0 INTRODUCTION

In many parts of their range polar bears have exhibited similar shifts in habitat use due to sea ice loss associated with climate change (Rode et al. 2015, Atwood et al. 2016b). As sea ice has declined, the number of polar bears coming on shore has increased (Rode et al. 2015, Atwood et al. 2016b) as has the length of time they spend there (Cherry et al. 2013, Rode et al. 2015, Atwood et al. 2016b). Aside from the potential negative demographic effects of longer periods on shore (Molnár et al. 2010), increased use of onshore habitat has led to higher incidences of human-polar bear conflict in some regions (Dyck 2006, Towns et al. 2009). In two studies of polar bears killed by humans in northern Canada, researchers found that the majority of polar bears killed in defense-of-life occurred during the open water season (Stenhouse et al. 1988, Dyck 2006). Thus, as more bears come on shore during summer, and spend longer periods of time on land, there is an increased risk of conflict between humans and nutritionally-stressed bears. This has the potential to result in more defense-of-life kills of polar bears and disruption to industrial, recreational, and subsistence activities conducted by humans.

Previous research has shown that use of onshore habitat by polar bears during summer and autumn is not randomly distributed (Schliebe et al. 2008, Cherry et al. 2013, Rode et al. 2015). For example, Rode et al. (2015) found that polar bear use of onshore areas in the Chukchi Sea was related to the date of sea ice retreat, with areas of coastline having later dates of retreat receiving greater use by bears. Further, when on shore, polar bears have been shown to be disproportionately distributed along barrier islands rather than mainland coastal areas (Gleason and Rode 2009). Polar bears also appear to be drawn to areas with human attractants, such as dumps (Lunn and Stirling 1985, Towns et al. 2009) and the remains of subsistence marine mammal harvests (Schliebe et al. 2008, Miller et al. 2015). While polar bear onshore distribution has been linked to biotic and abiotic factors, it remains unclear what the relative roles each of these factors are in determining polar bear abundance and distribution while onshore.

Determining the relative influence of sea ice conditions, onshore habitat, and human activities on areas where bears occur onshore is important for understanding how to best mitigate human-polar bear conflict. For example, if polar bears are drawn to communities primarily due to subsistence whale remains, then moving the remains away from the community might be an appropriate means of reducing conflict. Conversely, if bears are drawn to the area primarily due to onshore habitat conditions (e.g., more barrier islands) or preferable sea ice dynamics, such as earlier return of sea ice, then mitigation to remove attracts might be less effective. While the primary threat to polar bears is loss of sea ice habitat due to anthropogenic climate change (Regehr e al. 2016), methods to reduce the numbers of bears killed in defense-of-life could also have a positive effect on population persistence (Atwood et al. 2016a).

We developed a Bayesian state-space model to estimate the weekly number and distribution of polar bears along the northern coast of Alaska based on 14 years of aerial survey data and systematic ground-based counts from late August through October between 2000 and 2014. Because we estimated polar bear abundance and distribution as functions of variables related to sea ice conditions, onshore habitat, and human attractants, we were able to use the model to predict how effective different management strategies associated with the remains of marine mammals from subsistence harvest might be for decreasing the number of polar bears adjacent to coastal communities in northern Alaska. Specifically, we addressed how two strategies for handling subsistence-harvest bowhead whale (*Balaena mysticetus*) remains might affect the number of bears adjacent to the community of Kaktovik, Alaska, where large aggregations of polar bears can be found within and adjacent to the community in autumn (Miller et al. 2015).

4.0 METHODS

4.1 Aerial surveys

We flew aerial surveys during late summer and autumn annually between 2000 and 2014, except during 2006 when no surveys were flown. Surveys occurred between early August and late October, but varied between years. Therefore, we restricted our period of interest between the last week of August and the last week in October because these periods were represented in most years of the survey. The majority of surveys occurred between Utqiaġvik (formerly Barrow), Alaska and the Canadian Border (Fig. 1) along the mainland coast and barrier islands, although poor weather conditions often limited our ability to complete all sections of coastline during each survey week. Additionally, from 2000-2002, surveys were restricted to the area between Cape Halkett and Kaktovik (Fig. 1).

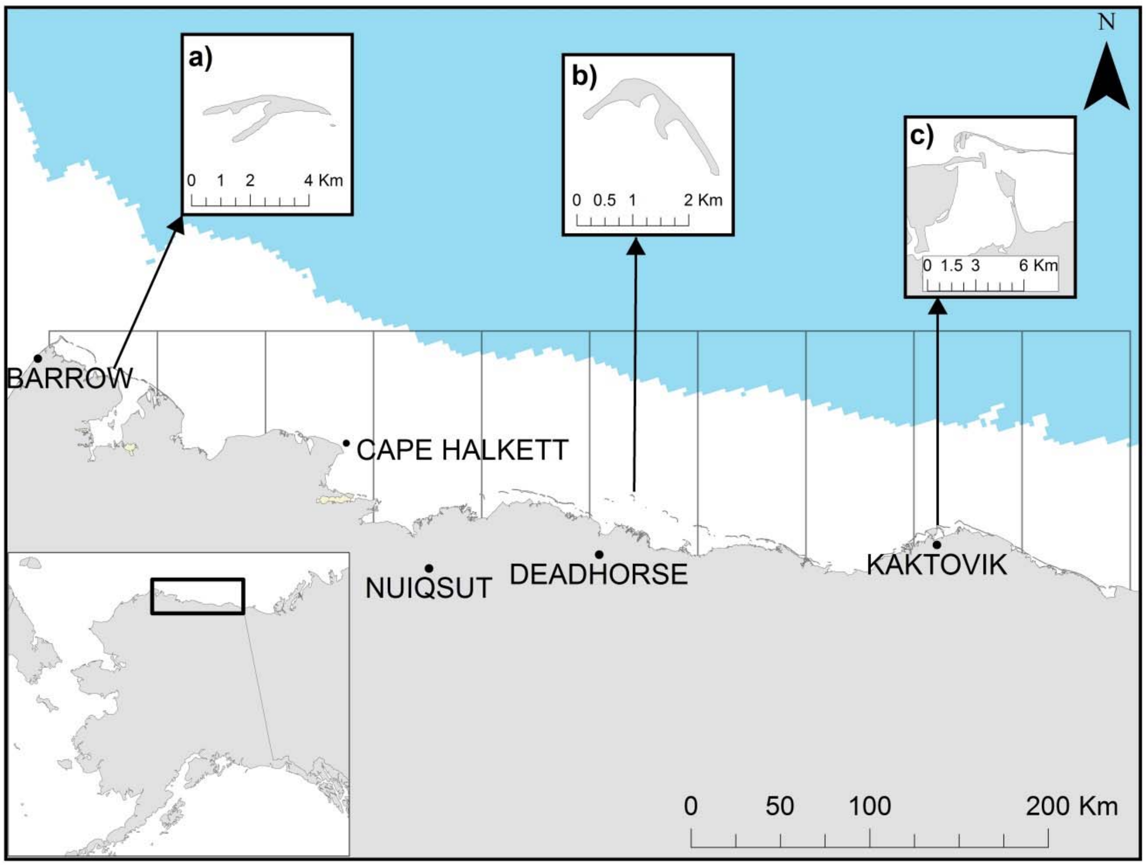

Figure 1. Depiction of the study area along the Beaufort Sea coast from Barrow, Alaska in the west to the Canadian Border in the east. The grids represent the 10 sub-regions of the study area for analysis, white offshore areas are over the continental shelf (i.e., <300 m depth), whereas the blue offshore area represent deeper waters (i.e., >300 m depth). Sub-figures depict the location of focal count areas used in the analysis: a) Cooper Island, b) Cross Island, and c) Barter Island.

Three separate aircraft types were used for surveys during the study; a Turbo Commander plane from 2000-2008, an R-44 helicopter from 2009-2010 and 2012-2014, and a Bell 206 helicopter in 2011. During surveys all aircraft flew approximately 300 m offshore and attempted to fly at an altitude of approximately 90 m at a speed of 150-185 km^{-hr}. We implemented a double-observer design, whereby a front and rear observer would independently spot groups of polar bears. Once it was no longer possible for either observer to see the group, observers would indicate whether they observed the group or not. Across all aircraft types, we estimated very high detectability (98.2%; 95% C.I. 97.5 – 98.7) of polar bear groups, likely due to the low altitudes we flew and the stark contrast between bears and coastline substrates. Thus, to simplify our modeling, we assumed that polar bears were observed 100% of the time if they occurred on the coastline.

4.2 Ground-based surveys

We supplemented the aerial survey dataset with three additional datasets of daily, systematic ground-based counts of polar bears from Cooper Island (Fig. 1a), Cross Island (Fig. 1b), and Barter Island (Fig. 1c). For each set of counts, we obtained the maximum number of bears observed during a daily count, during a given week for input into the model (see below, *Bayesian analysis*). During most years of the study, counts on Cooper Island were restricted to the last week of August, with two years providing counts during the first week of September, 2000-2014. Counts on Cooper Island were conducted from a fixed point, and covered a distance of approximately 4 km of coastline. Counts on Cross Island occurred from 2002-2004 during mid-September through the end of the month (corresponding to the period when whaling occurred). Counts were from a fixed location on the island, but observers were able to count bears over the entire island, totaling approximately 5 km of coastline. Barter Island counts occurred during September each year between 2002 and 2014. Counts on Barter Island were made along a road transiting the northern end of Kaktovik and from two fixed locations that allowed observers to count polar bears along the adjacent barrier island, totaling approximately 12 km of coastline.

4.3 Analytical methods

Changes in the area surveyed across the study, incomplete sampling of the survey area due to weather, and the incorporation of auxiliary polar bear count data necessitated the use of a Bayesian state-space modeling framework to estimate onshore abundance of polar bears. By implementing a fully Bayesian model, we were able to account for the additional levels of uncertainty in the data as well as incorporate ground-based count data which helped to supplement periods when there was no data from aerial surveys. Our goal was to estimate the number of bears along the coastline (i.e., a linear feature) and not estimate the total number of polar bears on land during summer.

4.4 Process model

The true number of polar bears, *N* on the coastline during week *w*, of year *y*, was modeled as a latent variable in the form

$$N_{y,w} \sim pois\left(exp\left(\beta_{N0} + \boldsymbol{\beta_N} \boldsymbol{x_{N_{y,w}}}\right)\right) \qquad (1)$$

where β_{N0} is an intercept term, $\boldsymbol{\beta_N}$ is a five-element vector of regression coefficients and $\boldsymbol{x_{N_{y,w}}}$ is the set of five explanatory variables present during week *w*, of year *y*. Specifically, $\boldsymbol{x_{N_{y,w}}}$ is represented by variables describing the weekly area of ice over the continental shelf, the annual date of ice retreat from the continental shelf, date of ice return over the continental shelf, the annual maximum distance from the ice edge to shore, and the average body mass index (BMI) of adult male polar bears from the SB subpopulation captured each spring.

We also modeled the true proportion, $\boldsymbol{\pi}$, of $N_{y,w}$ within each grid, g, as

$$\boldsymbol{\pi}_{\boldsymbol{y,w}} \sim dirch\left(exp\left(\beta_{n0} + \boldsymbol{\beta}_{\boldsymbol{n}} \boldsymbol{x}_{\boldsymbol{n}_{y,w,g}}\right)\right) \quad (2)$$

where β_{n0} is an intercept term, $\boldsymbol{\beta}_{\boldsymbol{n}}$ is a six-element vector of regression coefficients and $\boldsymbol{x}_{\boldsymbol{n}_{\boldsymbol{y,w,g}}}$ is the set of six explanatory variables present during week w, of year y, in grid g. Specifically, $\boldsymbol{x}_{\boldsymbol{n}_{\boldsymbol{y,w,g}}}$ is represented by variables describing whether a grid contains community that harvests bowhead whales, the weekly area of ice over the continental shelf within a grid, the annual date of ice retreat from and return to the continental shelf within a grid, the length of barrier islands within a grid, and whether a harvested bowhead whale carcass is present or absent in a grid during each week and year of the study. The estimated number of bears present across grid cells each week is therefore represented as,

$$\boldsymbol{n}_{\boldsymbol{y,w}} = N_{y,w} \boldsymbol{\pi}_{\boldsymbol{y,w}} \quad (3)$$

4.5 Observation model

We modeled the number of polar bears observed during a survey as a function of $n_{y,w,g}$ and of the proportion of a grid surveyed. Given that bears are not equally distributed on barrier islands or the mainland coast, we needed to account for what proportion of each were sampled. We therefore modeled the effective proportion of each grid sampled as

$$logit(\partial_{y,w,g}) = \beta_{\partial 0} + \beta_{\partial 1} m_{grid_{y,w,g}} + \beta_{\partial 2} b_{grid_{y,w,g}} + \alpha_{y,w,g} \quad (4)$$

where $\partial_{y,w,g}$ is the effective proportion of grid g surveyed, $\beta_{\partial 0}$ is an intercept term, $\beta_{\partial .}$ are regression coefficients, $m_{grid_{y,w,g}}$ is the proportion of the mainland coast flown in a grid, $b_{grid_{y,w,g}}$ is the proportion of barrier island coast flow in a grid, and $\alpha_{y,w,g}$ is a random effect. The observed number of bears in a grid during a survey, $\mathrm{n}_{\mathrm{obs}_{\mathrm{y,w,g}}}$, was then modeled as

$$\mathrm{n}_{\mathrm{obs}_{\mathrm{y,w,g}}} \sim \begin{cases} 0, & \textit{if a grid was not surveyed} \\ bin\left(\partial_{y,w,g}, n_{y,w,g}\right), & \textit{if a grid was surveyed} \end{cases} \tag{5}$$

Finally, the counts of polar bears on Barter ($\boldsymbol{Ba_{obs}}$), Cross ($\boldsymbol{Cr_{obs}}$), and Cooper Islands ($\mathbf{Co_{obs}}$) were modeled as a function of the number of bears in the respective grids (9, 6, and 1, respectively) and an estimate of the proportion of bears in each of the three grids ($\theta_{Ba_{y,w}}, \theta_{Cr_{y,w}}, \theta_{Co_{y,w}}$), found on the islands. Observed counts were then modeled as

$$\mathrm{Ba}_{\mathrm{obs}_{\mathrm{y,w}}} \sim pois\left(n_{y,w,9}\theta_{Ba_{y,w}}\right) \tag{6}$$

with Cross and Cooper Islands being modeled similarly.

All regression coefficients (i.e., β_*) and random effects (i.e., α) were given a vague normal prior with mean zero, and precision (i.e., 1/variance) of 0.1. Parameters for the proportion of bears in a grid counted by direct island counts ($\theta_{Ba_{y,w}}, \theta_{Cr_{y,w}}, \theta_{Co_{y,w}}$) were all given uniform priors ranging from 0 to 1. The full conditional distribution for our model is:

$$\begin{gathered}\left[\boldsymbol{\beta_\rho}, \boldsymbol{\beta_N}, \boldsymbol{\beta_\partial}, \boldsymbol{\beta_n}, \boldsymbol{\alpha}, \boldsymbol{\theta_{Ba}}, \boldsymbol{\theta_{Cr}}, \boldsymbol{\theta_{Co}}, \boldsymbol{N}, \boldsymbol{n} | \mathbf{n_{obs}}, \mathbf{Ba_{obs}}, \mathbf{Cr_{obs}}, \mathbf{Co_{obs}}\right] \propto \\ [\boldsymbol{N}|\boldsymbol{\beta_N}][\mathbf{n_{obs}}|\boldsymbol{n}, \boldsymbol{\beta_\partial}, \boldsymbol{\alpha}][\boldsymbol{n}|\boldsymbol{N}, \boldsymbol{\beta_n}][\mathbf{Ba_{obs}}|\boldsymbol{n}, \boldsymbol{\theta_{Ba}}] \times \\ [\mathbf{Cr_{obs}}|\boldsymbol{n}, \boldsymbol{\theta_{Cr}}][\mathbf{Co_{obs}}|\boldsymbol{n}, \boldsymbol{\theta_{Co}}][\boldsymbol{\beta_\rho}][\boldsymbol{\beta_N}][\boldsymbol{\beta_\partial}][\boldsymbol{\beta_n}][\boldsymbol{\alpha}][\boldsymbol{\theta_{Ba}}][\boldsymbol{\theta_{Cr}}][\boldsymbol{\theta_{Co}}]\end{gathered} \tag{7}$$

4.6 Model implementation

We estimated the posterior distribution for each parameter with Monte Carlo Markov Chains (MCMC) using the package 'rjags' (Plummer 2015) to run the program JAGS (Plummer 2003) from the R language and environment for statistical computing (Team 2014). We initialized two chains with separate starting values and allowed a burn-in period of 2,000,000 iterations. We then obtained 1,000,000 iterations from each chain, and thinned each by 100, resulting in a total of 20,000 samples from the posterior distribution. We visually assessed each parameter for convergence. We did not employ model selection, but rather assessed parameter estimates based on whether their 95% credible intervals (C.I.) overlapped zero, similar to Hobbs et al. (2012).

We performed posterior predictive checks (Chambert et al. 2014) to determine how well the model fit our observed data (i.e., n_{obs}). We calculated Bayesian *P* values for four test statistics (i.e., mean, standard deviation, discrepancy, and goodness of fit) and considered *P* values for test statistics between 0.1 and 0.9 to indicate a good fit between the model and observed data for a given test statistic (Hobbs and Hooten 2015).

4.7 Management strategy assessment

Kaktovik, Alaska is small community of approximately 250 residents. As presented earlier, each autumn, whaling crews attempt to harvest the community's allotment of bowhead whales (typically 1-3 whales). Once a whale is caught, it is brought to the community to be butchered, and shares of the whale divided among community members. Butchering occurs along the shore of the lagoon in Kaktovik, <0.5 km from residential areas. Similarly, shares of the whale are left <0.5 km from residential areas as they await distribution to community members; usually unattended. Polar bears are frequently observed adjacent to the butchering location and the site of the whale shares. After the whale has been fully butchered, the carcass is transported to the end of a spit along the community's road system, approximately 2.5 km from residential areas. Each autumn, the site of whale remains (hereafter, bone pile) draws large aggregations of polar bears, primarily at night (Miller et al. 2015).

Due to the large number of bears that occur in and around Kaktovik and the risk to public safety and the potential for polar bears to be killed in defense-of-life, we sought to use the results from our modeling efforts to determine if alternative strategies for the management of the bowhead whale harvest could lead to a meaningful reduction in the number of polar bears occurring adjacent to Kaktovik in autumn. Specifically, we assessed the following strategies which have been proposed at various times by members of the community: 1) the whale carcass is taken offshore and dumped in the ocean, and 2) the whale carcass is moved to a section of beach away from the community. To assess strategy 1 (S1), we modified the 'whale carcass present/absent' variable to be 0 during all weeks for the grid containing Kaktovik. For strategy 2 (S2), we followed the same modifications as S1, except we set the 'whale carcass present/absent' variable in the grid to the east of the Kaktovik grid to be 1 during all weeks when a carcass was observed to present in Kaktovik. For each strategy, all other observed variables were kept the same as originally observed. We then predicted the number of polar bears in the grid containing Kaktovik each week of the study under each scenario in the same MCMC routine described above. We then calculated the mean percent change in the number of bears in the grid containing Kaktovik across all weeks of the study, compared to the original predictions from the observed dataset.

5.0 RESULTS

We flew a total of 53 surveys between 2000 and 2014, with an average of 3.8 (SD=0.97) surveys flown per year. The distance flown in each survey varied (Table 1), but was on average 961 km (SD=36.3 km). The mean number of polar bears observed during a survey was 64 (SD=36), with a maximum of 156 observed during the late August survey of 2012. Corrected for survey distance, the mean number of polar bears counted per 100 km of survey was 7 (SD=4). We obtained polar bear counts on Cooper, Cross, and Barter Islands during a total of 27, 9, and 59 weeks of the study, respectively. On Cooper Island, we observed an average of 0.7 (SD=1.1) individual polar bears during each survey week, with a maximum of 5 bears observed during late August in 2002. On Cross Island, we observed an average of 6.4 (SD=3.8) individual polar bears during each survey week, with a maximum of 13 bears observed the week of 19 September of 2004. Finally, on Barter Island, we observed an average of 35.2 (SD=17.7) individual polar bears during each survey week, with a maximum of 80 polar bear observed during the week of 12 September 2012.

Table 1. Summary table of average distances flown during each survey and within each grid. Data are also provided on the total length of transects available to be flown, and what percentage of the coastline and each grid were made up of barrier islands and mainland coastline.

		Distance flown (km)		Percent of survey (%)	
Survey segment	Transect distance (km)	$\bar{x}$	SD	Barrier islands	Mainland coastline
Total	1387	962	363	33.6	66.4
Grid					
1	170	139	32	36.0	64.0
2	110	96	20	7.4	92.6
3	151	129	37	12.1	87.9
4	92	81	16	11.0	89.0
5	143	132	23	49.5	50.5
6	170	130	36	42.2	57.8
7	132	116	21	47.4	52.6
8	113	90	25	37.3	62.7
9	166	143	34	48.8	51.2
10	140	123	34	39.6	60.4

5.1 Model evaluation

There was no indication of a lack of convergence for the model and all parallel chains converged on the same set of values. We did not observe any significant evidence of a lack of fit from our posterior predictive checks. Bayesian *P* values for the estimate of the total number of bears within each grid indicated a good model fit for each metric; mean ($P = 0.51$), standard deviation ($P = 0.58$), discrepancy ($P = 0.50$), and goodness-of-fit ($P = 0.47$).

5.2 Model results

We estimated the mean annual number of polar bears onshore during our study was 140 (95% C.I.; 127 – 157). While there was considerable variation in the weekly estimates of the number of bears on shore in the study region, we found no evidence suggesting an increasing trend in the number of polar bears on shore during the period of our study (Fig. 2). There was a general trend for decreasing numbers on bears onshore in late October (Fig. 2), coincident with the return of sea ice; although this seemed to be present more frequently prior to 2009 (Fig. 2).

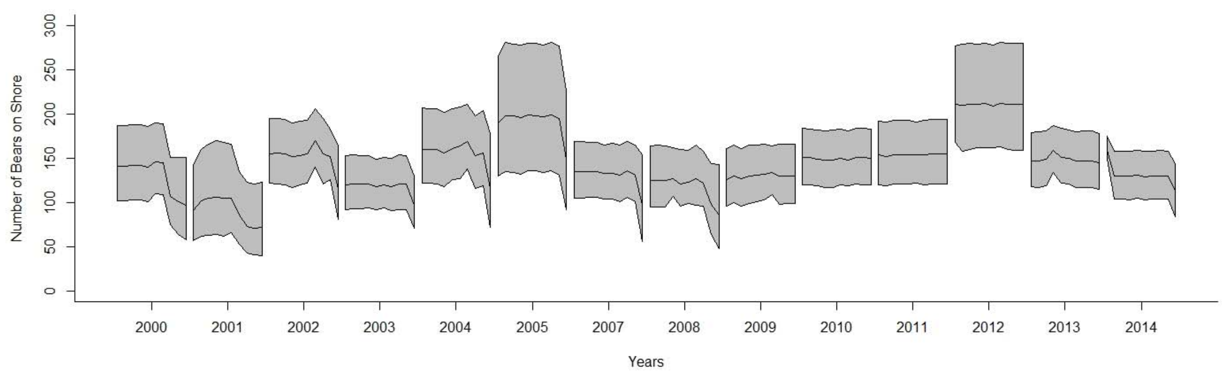

Figure 2. Weekly population size estimates of polar bears along the coastline of northern Alaska, from Barrow, Alaska to the Canadian Border, 2000-2014, excluding 2006.

The number of polar bears on shore each week was significantly related to sea ice conditions (Table 2). The most significant predictors of the number of bears on shore was the date of ice retreat and return, with more bears being on shore in years with later dates of ice retreat and return (Table 2). We found marginal support for the variable associated with the amount of ice over the continental shelf, with fewer bears estimated to be onshore with increasing levels of sea ice over the continental shelf (Table 2). A similarly marginal relationship between weekly numbers of bears on shore and the maximum distance to sea ice from shore existed, with more bears estimated to be on shore in summers when ice was further from shore (Table 2). We found no evidence of average adult male BMI from the preceding spring capture season having an impact on the number of bears on shore (Table 2).

Table 2. Summary statistics for coefficient estimates used to estimate the weekly number of polar bears along the northern Alaska coastline (*N-parameters*) and their distribution (*n-parameters*) between the last week of August and the last week of October, 2000-2014, excluding 2006.

				Quantile	
Parameter	Mean	Median	SD	0.025	0.975
N-parameters					
Intercept	4.03	4.03	0.29	3.46	4.60
Ice Area	-0.40	-0.41	0.23	-0.83	0.08
Ice Retreat Date	0.71	0.70	0.30	0.14	1.29
Ice Return Date	1.04	1.04	0.40	0.24	1.81
Max Distance to Ice	0.43	0.43	0.25	-0.06	0.91
Male BMI	-0.34	-0.33	0.40	-1.12	0.46
n-parameters					
Intercept	-0.12	-0.11	0.47	-1.06	0.79
Whale Community	0.18	0.18	0.26	-0.33	0.71
Ice Area	0.77	0.78	0.54	-0.31	1.83
Ice Retreat Date	-1.06	-1.07	0.49	-1.99	-0.07
Ice Return Date	-0.37	-0.38	0.45	-1.24	0.53
Barrier Islands	0.64	0.65	0.30	0.03	1.21
Whale Carcass	2.07	2.07	0.24	1.61	2.56

The estimated distribution of bears across the coast of northern Alaska was not uniform (Fig. 3). Grid 9 had the highest estimated number of polar bears, with approximately 35% of polar bear onshore occurring there, on average, followed by grid 6 with approximately 25% (Fig. 3). Within Grid 9, 63.8% (95% C.I.; 58.4–68.9) of bears were estimated to be located on or adjacent to Barter Island. Within Grid 6, 25.1% (95% C.I.:14.4–38.8) were estimated to be on Cross Island.

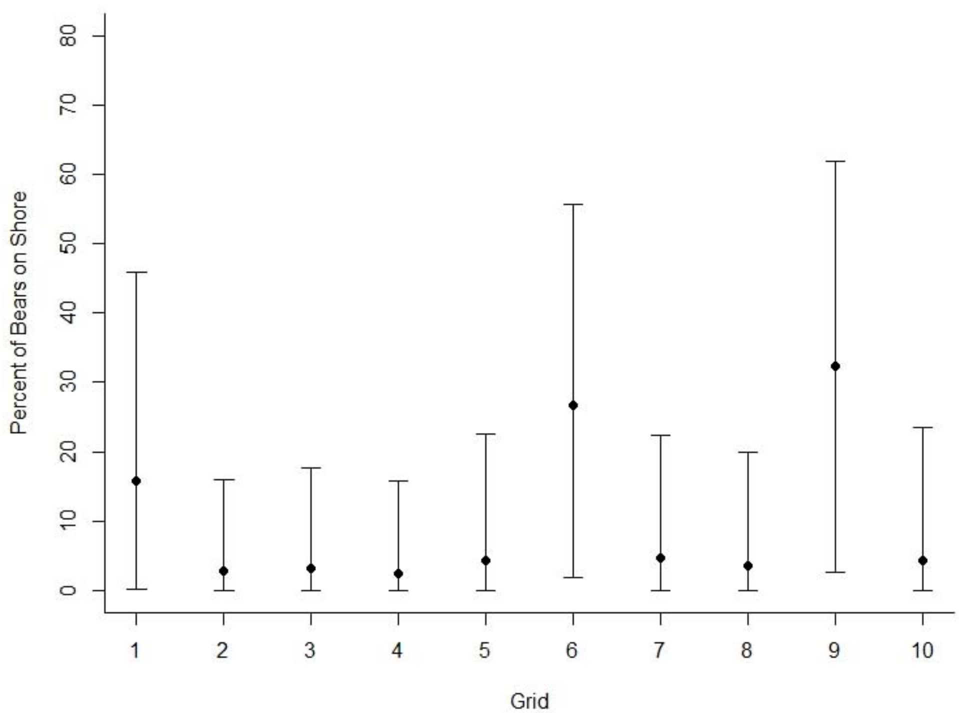

Figure 3. Estimates of the mean percent of polar bears on the coastline of northern Alaska that occurred in each of 10 study grid cells during the study period, the last week of August through the last week of October, 2000-2014, excluding 2006.

The two predominant factors that affected the distribution along the coastline were the date that sea ice retreated from a grid and the presence/absence of a whale carcass in that grid (Table 2). Bears were more likely to be distributed in sections of coast with earlier dates of ice retreat and a whale carcass present (Table 2). The distribution of bears was also positively affected by the abundance of barrier islands along the coast (Table 2).

5.3 Management strategy

We observed significant reductions in the proportion of polar bears onshore adjacent to Kaktovik under both management scenarios compared to baseline conditions. Under S1, we found that disposing of whale carcasses in the ocean reduced the number of bears adjacent to Kaktovik by 75% (95% CI: 65-84). Similarly, under S2 we found that moving whale remains further down the coast resulted in a 79% (95% CI: 69-87) reduction in the number of bears adjacent to Kaktovik.

6.0 DISCUSSION

We found significant relationships between the number and distribution of polar bears on the coastline of northern Alaska and factors related to sea ice dynamics and anthropogenic activities. Thus, the distribution of polar bears on the northern Alaska coastline is affected by both sea ice conditions and anthropogenic influences. Our results suggest that approximately 15% of the SB subpopulation (Bromaghin et al. 2015) occurs along the northern Alaska coastline during any given week between late August and late October. Although we found no overall trend in the annual mean number of polar bears along the northern Alaska coastline, the fact that we estimated the highest number of bears onshore in 2012, the year of the recorded minimum sea ice was recorded (Parkinson and Comiso 2013), implies that future sea ice loss could result in an increase of bears using land in summer. This is also evident by our finding that the number of bears along the coastline is positively (albeit marginally) affected by reductions in the amount of ice over the continental shelf and increases in the distance to the edge of pack-ice. We did observe a shift towards more bears on the coastline later into autumn after 2008, suggesting that polar bears are staying longer on land before heading back to the sea ice. This is a common trend observed by polar bears in relation to sea ice loss (Cherry et al. 2013, Rode et al. 2015, Atwood et al. 2016b).

We were somewhat surprised that we did not detect an increasing trend across years of the number of bears estimated to be on the coastline given that Atwood et al. (2016b) found a significant increase in the proportion of collared adult females in the SB subpopulation using land during summer over a similar time frame. The discrepancy could be the result of numerous issues. A simple explanation could be that the uncertainty around our estimates of N were too large to detect an increasing trend during our study period. Alternatively, our analysis estimated the total number of polar bears on the coastline, including all age and sex classes, whereas the study by Atwood et al. (2016b) was restricted to adult females fitted with tracking collars. Thus, if only adult females have shifted to increased land use, or are the last group to adopt this behavior, then it could be reasonable to expect no increasing trend in land use. Few studies have compared adult female polar bear space use patterns to other age and sex classes given the difficulty of attaching collars to these groups. Of the few studies that have compared space use patterns, however, minimal differences were observed (Amstrup et al. 2001, Laidre et al. 2013). We believe the most likely explanation for the apparent discrepancy between our results and those of Atwood et al. (2016b) is that they estimated the proportion of adult females coming onshore whereas we estimated the absolute number of bears using the northern Alaskan coastline. If the size of the population remained stable during the course of our study, then those two metrics should remain comparable. This is not the case, however, as capture-recapture studies suggest that the population size of the SB subpopulation has decreased from approximately 1,500 animals in 2004 to approximately 950 in 2010 (Bromaghin et al. 2015). Therefore, even if an increasing proportion of the population is using land, the absolute number may not have increased due to the concomitant decrease in population size during the study period.

Polar bears were not equally distributed along the coastline. The distribution of polar bears was influenced by ice phenology, presence of barrier islands, and presence of whale remains. Polar bears disproportionately occurred in sections of coast with earlier dates of ice retreat. These results are similar to polar bears in western Hudson Bay that came on shore earlier when ice retreated earlier (Cherry et al. 2013). Thus, it may be that bears are choosing to come on shore slightly earlier compared to other sections of coastline, to minimize the distance or need to swim to shore given the high energetic costs of swimming (Durner et al. 2011, Pagano et al. 2012). Interestingly, the presence of a whale carcass was greater than 11 times more important for determining the number of bears in a grid than whether the grid contained a whaling community. This implies that polar bears in northern Alaska are not primarily drawn to communities due to other attractants such as dumps (Lunn and Stirling 1985). Thus, management activities associated with how whale carcasses are handled are likely to be most influential in reducing human-polar bear conflict in the region.

Diversionary feeding has been suggested a possible management tool for redistributing polar bears currently adjacent to communities (Derocher et al. 2013). Our results suggest that in the case of bears adjacent to Kaktovik, Alaska, if subsistence-harvested whale carcasses were moved down shore from the community there could be a significant reduction in the number of bears near the community. This has been found numerous times in studies of black bears (*Ursus americanus*). If sufficient food resources are available away from areas of human development, black bears will shift their space use away from human development (Johnson et al. 2015). Similarly, Stringham and Bryant (2015) found that diversionary feeding sites for black bears significantly reduced human-bear conflict, and that the rate of reduction in conflicts was a function of how far the feeding site was from a community. Therefore, if moving the carcass down the shoreline is the chosen strategy for dealing with polar bear conflict in Kaktovik, additional research should be conducted to determine the optimal distance for the whale to be moved so bears can be significantly displaced from the community but still quickly find the carcass.

A key difference between management scenarios is the availability of a whale carcass; where under S1 no carcass remains, but under S2 one does remain, but in a different location. While we found similar results in the reduction of polar bears adjacent to Kaktovik for both scenarios, the results of S1 might be overly optimistic if bears do not move elsewhere along the coast to find other sources of food (e.g., beach-cast marine mammal carcasses). For example, Ziegltrum and Russell (2004) found that when supplemental food was removed for black bears, damage to conifers in plantations increased seven-fold. Clearly this a different set of conditions than those present for polar bears, but it implies that removal of an expected food source could lead to increased human conflict. Removing the whale carcass could also increase the importance of communities to polar bears beyond what we found in this model. A similar pattern emerged with grizzly bears (*Ursus arctos*) in Yellowstone National Park, Wyoming, after dumps were shutdown (Craighead and Craighead 1971), grizzly bears increasingly used campgrounds, leading to a significant increase in conflict with humans and subsequently a large increase in bears shot and killed (Craighead and Craighead 1971). Thus, an immediate and complete elimination of whale carcasses could have an effect opposite of that desired. Still, our model results for S1 likely reflect that there would be some reduction in bears adjacent to Kaktovik given that such a large food subsidy had been removed.

Our management scenario analysis makes a number of assumptions that are important to consider when interpreting the results. We assume that if a whale is disposed of offshore, that the lack of carcass has no effect on the total number of bears that come to shore. We did not link the weekly estimate of *N* to any variable associated with whale harvest because in all years of the study, communities harvested whales. Thus, if lack of carcasses near Kaktovik reduces the number of bears coming onshore, our estimated reduction in bears adjacent to Kaktovik is likely underestimated. We also assume that there is no time lag between the management action and bear redistribution along the coast. The time lag is likely to differ between the two scenarios, with bears likely able to respond in near-real time to moving a carcass down the coast, especially if the same location was used every year. Others have shown that black bears, for example, can quickly shift space use to reflect new food resources (Stringham and Bryant 2015) or improved quality of existing food resources (Johnson et al. 2015). Conversely, polar bears might take multiple years to move away from Kaktovik if the carcass were disposed offshore given that there was no 'new' attractant to exploit. This is especially true with evidence suggesting use of subsistence-harvested whales is learned, rather than opportunistic (Herreman and Peacock 2013). This has also been shown for other sources of human-derived foods for polar bears (Lunn and Stirling 1985). Given these uncertainties, even though the estimated reduction in polar bears adjacent to Kaktovik was similar between scenarios, S2 might be the most likely to have a quicker realization of the desired management outcome.

Our study reaffirms an important variable that has been emerging as a key predictor in the relationship between changing sea ice conditions and polar bear ecology; the area of sea ice over the continental shelf or how much of the year it remains there. It has also been shown as a key variable for predicting the number of days polar bears spend on shore (Rode et al. 2015, Atwood et al. 2016b) and survival (Regehr et al. 2010, Stirling et al. 2011). It was also a primary factor that Rode et al. (2014) found described the significant differences in body mass and productivity of two adjacent polar bear subpopulations. We recommend that future work continue to assess how polar bear ecology is linked to less ice over the continental shelf. Additionally, research should focus on better understanding the tradeoffs between remaining on the sea ice during summer and autumn versus coming to shore. It also is important to continue to seek ways to integrate multiple data sets into the same analytical framework, which is possible due to recent advances in Bayesian modeling frameworks (Hobbs and Hooten 2015). This can be necessary to derive useful results from sampling designs similar to ours where some methods provide incomplete survey data (e.g., helicopter surveys due to weather) and other survey methods (e.g. ground-based counts) are available to help fill in data gaps.

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and does not imply endorsement by the US Government. This research was permitted under the Marine Mammal Protection Act and Endangered Species Act under US Fish and Wildlife Service permit MA046081 and followed protocols approved by Animal Care and Use Committees of the US Fish and Wildlife Service.

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9.0 APPENDIX I: RADIOTELEMETRY TAG DEVELOPMENT

This appendix describes activities under IAA M09PG00024 related to Objective 2) "Evaluate the performance of new satellite telemetry tags". Since 2009, USGS and USFWS have deployed two types of non-collar telemetry tags (glue-on and ear-mounted) to track polar bear movements as alternatives to using radio collars. These tags provide the opportunity to gather movement data on sex and age classes other than adult females. They may also reduce risks to animal welfare compared to radiocollars, which may cause rubs or cuts behind the ears of some bears that gain a lot of weight. The average retention time of early-model tags, deployed during spring research on the CS and SB subpopulations between 2009-2013, was approximately 58.8 days (SD = 31.4 days).

Starting in 2013, with the support of BOEM under IAA M09PG00024, USFWS began to work with multiple manufacturers of wildlife telemetry tags, with the primary goals of (1) increasing the retention time of non-radio collar tags, (2) reducing the size of the tags, and (3) modifying the antenna to avoid failure due to icing. In 2014, we paired up with Lotek/Sirtrack and the Washington State University to test three newly-designed ear tag prototypes on captive grizzly bears before deploying them on wild polar bears. This demonstrated that the tags could withstand the forces of a bear. Based on the positive results from this captive study we deployed 15 of the newly-designed ear-mounted during spring 2015 physical-capture research on the CS subpopulation. Although the results were not as positive as we had hoped, the average retention time improved to 73.4 days (SD = 50.5), suggesting incremental improvements resulting from our design changes.

In 2016, we made further changes by refining the tag attachment system and using a thinner antenna, originally developed for use on fish transmitters. It was our hope that the reduced surface area would minimize icing of the antenna. However, the two thin-antenna tags that were deployed only transmitted for an average of 20.5 days (SD = 9.2). Six other tags that were deployed with standard antennae, but a new attachment mechanisms, transmitted an average of 66.3 days (SD = 18.9). In addition to the slightly improved retention time with the 2015 and 2016 tags, we have been able to reduce the weight of the ear tag from approximately ~ 60 grams (dimensions 45 x 30 x 20 mm) to approximately 33 grams (dimensions 39 x 28 x 20 mm). We also changed the attachment system from a metal system to a polyurethane system which reduced the weight of the transmitter, as well as the potential to damage the bear's ear. We have since recovered 2 transmitters during the 2016 capture season and found no damage to the bears' ears (Fig. 9.1). Technical specifications of ear-mounted tags deployed on polar bears in the CS subpopulation in 2015 and 2016 are provided in Table 9.1.

Figure 9.1 A prototype ear-mounted radiotelemetry tag (model Sirtrack KiwiSat 202) recovered on a polar bear in the Chukchi Sea subpopulation on 14 April 2016.

Table 9.1 Ear-mounted radiotelemetry tags deployed on polar bears in the Chukchi Sea subpopulation during physical-capture research in the springs of 2015 and 2016. PTT ID is the unique Platform Transmitter Terminal identification code for the tag.

PTT ID	Serial number	Date deployed	Date of last location	Functional life (days)	Comments
146215	Sirtrack KiwiSat 202 ear tags	4/4/2015	8/5/2015	123	
146216	Sirtrack KiwiSat 202 ear tags	4/2/2015	5/22/2015	50	
146217	Sirtrack KiwiSat 202 ear tags	4/5/2015	5/22/2015	47	
146207	Sirtrack KiwiSat 202 ear tags	4/5/2015	5/30/2015	55	
146210	Sirtrack KiwiSat 202 ear tags	4/10/2015	5/10/2015	30	
146220	Sirtrack KiwiSat 202 ear tags	4/11/2015	6/7/2015	57	
146221	Sirtrack KiwiSat 202 ear tags	4/9/2015	5/30/2015	51	
146219	Sirtrack KiwiSat 202 ear tags	4/17/2015	5/10/2015	23	
146212	Sirtrack KiwiSat 202 ear tags	4/15/2015	6/19/2015	65	
146211	Sirtrack KiwiSat 202 ear tags	4/14/2015	6/27/2015	74	
146209	Sirtrack KiwiSat 202 ear tags	4/14/2015	7/9/2015	86	
146213	Sirtrack KiwiSat 202 ear tags	4/20/2015	5/10/2015	20	
146218	Sirtrack KiwiSat 202 ear tags	4/24/2015	8/18/2015	116	
146214	Sirtrack KiwiSat 202 ear tags	4/12/2015	11/18/2015	220	
146208	Sirtrack KiwiSat 202 ear tags	4/12/2015	7/5/2015	84	
154311	Sirtrack KiwiSat 202 ear tags	4/10/2016	6/20/2016	71	
154319	Sirtrack KiwiSat 202 ear tags	4/13/2016	4/27/2016	14	thin antenna
154315	Sirtrack KiwiSat 202 ear tags	4/13/2016	5/10/2016	27	thin antenna
154306	Sirtrack KiwiSat 202 ear tags	4/12/2016	5/27/2016	45	
154309	Sirtrack KiwiSat 202 ear tags	4/14/2016	7/24/2016	101	
154310	Sirtrack KiwiSat 202 ear tags	4/16/2016	6/17/2016	62	
154313	Sirtrack KiwiSat 202 ear tags	4/19/2016	6/20/2016	62	
154307	Sirtrack KiwiSat 202 ear tags	4/21/2016	6/17/2016	57	

USFWS and partners continue to solicit funding for research and development of radiotelemetry tags. The relatively small number of prototype tags deployed on polar bears in the CS subpopulation limits the value and statistical power of analyses of tag retention and performance. To overcome this limitation and make use of all available data, USFWS and USGS have collaborated on circumpolar analysis of non-radiocollar tag performance with researchers from Greenland, Canada, Denmark, and Norway. The following publication has been submitted for publication in a peer-reviewed journal.

Wiig, Ø., E. W. Born, K. L. Laidre, R. Dietz, M. V. Jensen, G. M. Durner, A. M. Pagano, E. Regehr, M. S. Martin, S. Atkinson, and M. Dyck. 2017. Performance and retention of lightweight satellite radio tags applied to the ears of polar bears (*Ursus maritimus*). Animal Biotelemetry **5**:9.

11.0 APPENDIX II: LETTER OF AUTHORIZATION REPORTING SYSTEM ENHANCEMENT PROJECT

This appendix describes activities under IAA M09PG00024 related to Objective 3) "Develop strategies to reduce the possibility that industrial development and changing environmental conditions will interact to the detriment of the polar bear population".

11.1 Introduction

USFWS maintains and operates a database called the Letter of Authorization Reporting System (LOARS). The function of the LOARS is to document federal authorizations of "take" under the MMPA and to document and collate polar bear observations and interactions reported by companies who have been issued Letters of Authorization (LOAs) under Incidental Take Regulations (ITRs) promulgated under the MMPA. The database also documents the determination of "take," as defined under the MMPA, and facilitates analysis and reporting of the LOAs and takes. LOA data are input by USFWS personnel, while input data for polar bears observations are taken from observation reports submitted by personnel of companies or their representatives that hold LOAs. The observation reports are submitted in a variety of formats including paper and electronic, PDFs and Microsoft Excel files. Data input is currently manually entered by designated USFWS personnel. Future functions of this database may include Pacific walruses (*Odobenus rosmarus divergens*) and northern sea otters (*Enhydra lutris kenyoni*).

11.2 Purpose of the LOARS Enhancement Project

The purpose of the LOARS Enhancement Project as supported by IAA M09PG00024 is to correct and enhance the existing LOARS. Corrections were needed to eliminate extraneous and redundant data structures, inconsistent storage of data, and erroneous results from data mining and reporting processes. Enhancements addressed the need for system and process documentation, robust and thorough data validation, flexible and reliable data submission and reporting tools, and a change management system.

11.3 Accomplishments of the LOARS Enhancement Project

11.3.1 System Usability

The LOARS user interface was redesigned to improve the efficiency and reliability of data entry, review, mining, and reporting. The interface was carefully aligned with common workflow scenarios, but offers the user multiple ways to efficiently navigate the system for exploring and utilizing the data in new ways. Microsoft Access tools have been fully leveraged to maximize the user's ability to enter, query, export, import, analyze, and present the data. This makes the database system more efficient for current purposes, but also adds flexibility for accommodating future needs. The time required to learn how to use the system will also be reduced as an extensive collection of tutorials and other training materials are available at no charge from Microsoft and other providers.

11.3.2 Documentation

A system requirements document was first developed to describe the "business" requirements that must be satisfied in order for the LOARS to be successful. These business requirements specify what the system must do, not how it is to be done. This requirements document will provide a standard to guide data and process quality control, quality assurance, and testing efforts. In addition, it will provide future custodians of the LOARS with background information regarding the goals and functions of LOARS.

The project requirements document includes: initial high-level project requirements; database entity relationship diagram; data entry, submission, validation, and reporting workflow;

known hardware and software requirements; and specifications for the change management system. This document will help new users, managers, and future developers to better understand, maintain, and enhance the system. A new user guide includes: a complete data dictionary with data item names, user interface label text, when-collected specifications, data types, field formats, required validations and derivations. The user guide also serves as the source for a context-sensitive in-application help system including a description of system procedures and operation.

11.3.3 Data Quality

Data-related “business” rules identified during the requirements gathering process have been implemented in an extensive data validation system. These include a visual feedback system within the database forms using both colors and symbols to flag required and/or missing data (Figs. 11.1 and 11.2). Invalid data entry is now more easily detected and prevented from being input, with informational error messages to the user. Textual feedback is also provided to warn of questionable data entry and to guide the user in correct data recording procedures. As noted above, the establishment and enforcement of data-related business rules is described in requirements documentation and in context-sensitive help content.

Upgraded system tools have been put to use in identifying and correcting data problems. Data quality improvements include identification and entry of missing data; correction of erroneous data; and elimination of redundant, obsolete, and conflicting data and data structures. Data quality improvements have been more complex and time consuming to implement than anticipated, but have dramatically increased the accuracy of reports and the quality of other data products.

11.3.4 Data Analysis and Reporting

Data structures and data objects have been thoroughly refactored - restructuring the existing computer code without changing its external behavior, to eliminate coded values. Data are now displayed exactly as stored in the database. This makes customized queries and reports simpler and more reliable to produce. In addition, new tools have been developed for generating automated reports of commonly summarized data (Table 11.1; Fig. 11.3). This will save time in producing future reports, and will eliminate inaccuracies in those products. The new reporting tools also offer capabilities for running predefined data validation and other queries.

11.3.5 Data Collection

The design of the database and the proposed data entry forms have been synchronized to capture all field-entered data and to better align data collection with information needs. The database design has been optimized to accept and store electronically captured information from external sources, such as photographs and observation forms. This will facilitate the future implementation of electronic forms or applications for data collection. A range of automated data submission strategies has been analyzed. While automated data submission from external sources has not yet been implemented, work accomplished can be utilized in later phases of the project.

11.3.6 PBHIMS Integration

The LOARS has been enhanced to include automated output to the Polar Bear – Human Information Management System (PBHIMS). PBHIMS is the circumpolar human-polar bear interaction database developed by the Polar Bear Range States Human - Polar Bear Conflict Working Group. The database is designed to capture standardized human-bear interaction data across the world-wide range of polar bears. The process of selecting and loading records to

PBHIMS has been automated, but can be easily tailored by the user for loading or excluding particular records or categories of records. Source data have been validated to ensure accurate translation from the LOARS to PBHIMS, and questionable situations are logged for review.

11.4 Conclusion

While the need for some additional system enhancements have been identified, the project goals of correcting fundamental data and system design flaws, improving data entry, reporting, and analysis capabilities have been achieved. The functionality of the database has been improved which will make the user interface more efficient for future data input and analysis.

Figure 11.1 An example of the LOA (Letter of Authorization) Details screen and fields in the Letter of Authorization Reporting System.

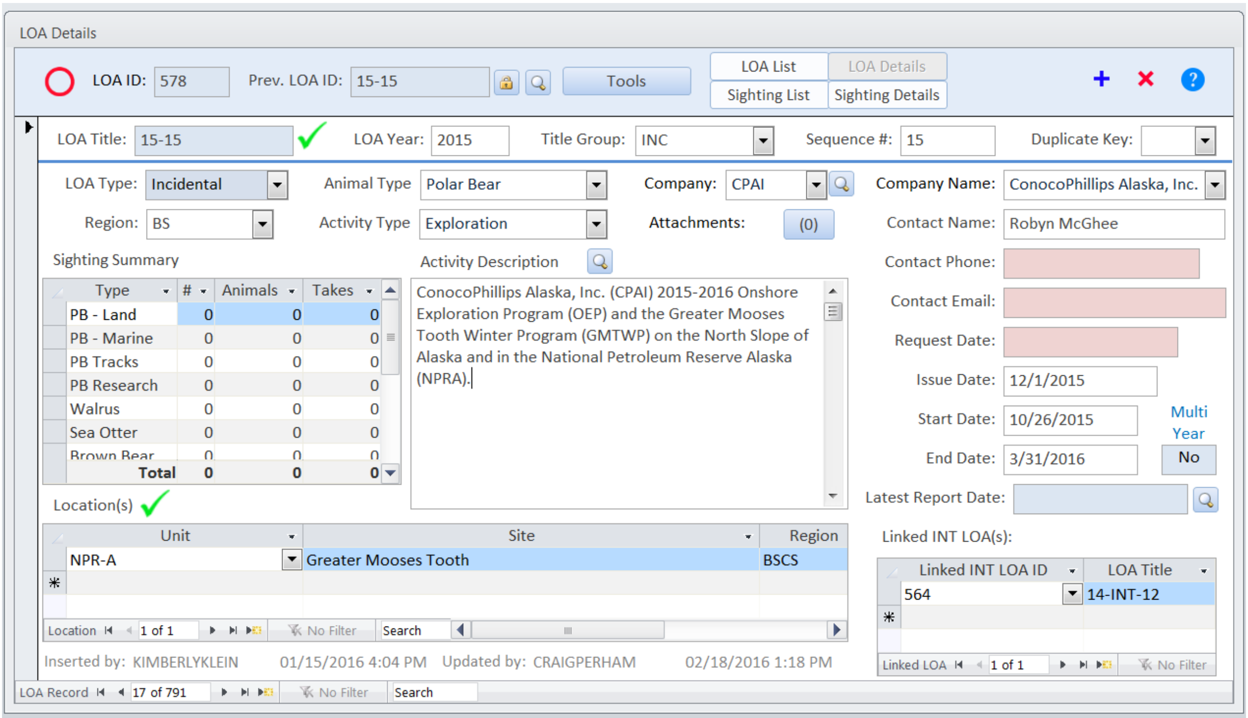

Figure 11.2 An example of the polar bear Sighting Details screen and fields in the Letter of Authorization Reporting System.

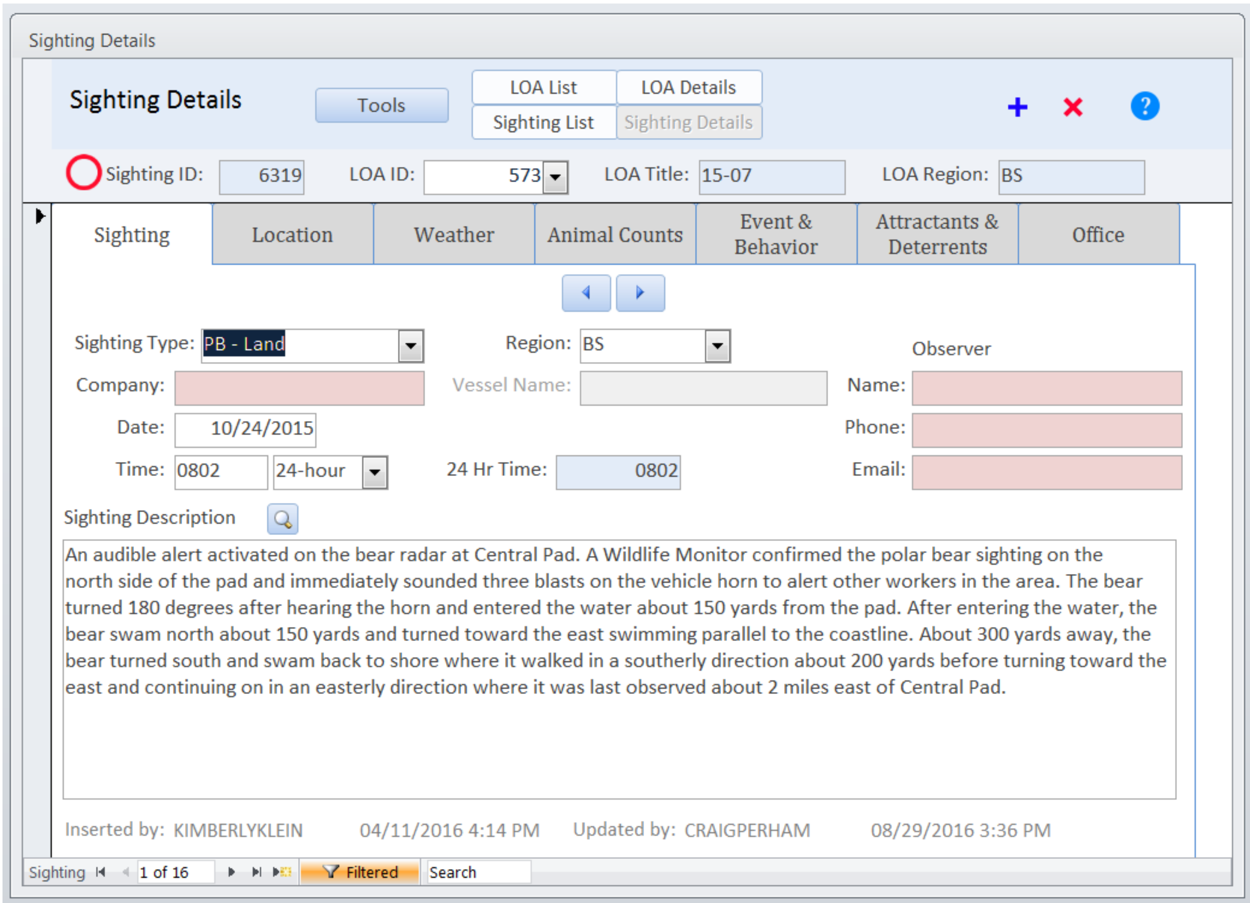

Table 11.1 A list of the data fields for the Letter of Authorization Reporting System output reports, including Report Type and Report Title.

Report Type	Report Title
Overall Annual	Overall Annual Report
LOA Count	Number of Incidental LOAs by Year
LOA Count	Number of Incidental LOAs by Year and Region
LOA Count	Number of Intentional LOAs by Year
LOA Count	Number of Intentional LOAs by Year and Region
Sighting Count	Number of Sightings by Year
Sighting Count	Number of Sightings by Year and Company
Sighting Count	Number of Sightings by Year and LOA
Sighting Count	Number of Sightings by Year and Region
Bear Count	Number of Bears Sighted by Year
Bear Count	Number of Bears Sighted by Year and Company
Bear Count	Number of Bears Sighted by Year and LOA
Bear Count	Number of Bears Sighted by Year and Region
Take Count	Number of Takes for Incidental LOAs by Year
Take Count	Number of Takes for Intentional LOAs by Year
Take Count	Number of Takes by Year and Company
Take Count	Number of Takes by Year and LOA
Take Count	Number of Takes by Year and Region
Bears Hazed Count	Number of Bears Hazed by Year
Bears Hazed Count	Number of Bears Hazed by Year and Company
Bears Hazed Count	Number of Bears Hazed by Year and Intentional LOA
Bears Hazed	Number of Bears Hazed by Year and

Count	Region
Bears Hazed Count	Number of Bears Hazed by Year and Deterrent

Figure 11.3 Example of Overall Annual Report for the Letter of Authorization Reporting System. Example Report is for the calendar year of 2014, the most recent year of complete data.

Overall Annual Report 2014

Number of Incidental LOAs: 33

Number of Incidental LOAs by Region

Region	Count
BS	32
CS	1
BSCS	0

Number of Intentional LOAs: 23

Number of Intentional LOAs by Region

Region	Count
BS	21
CS	0
BSCS	2

Number of Sightings: 354

Number of Sightings by Company

Company Name	Count
Alaska Gasline Development Coporation	0
Alaska Industrial Development and Export Aut	0
Alyeska Pipeline Service Co.	2
ARCTEC Alaska	8
BP Exploration (Alaska)	144
Brooks Range Petroleum Company	0
CGG Land US, Inc.	0
ConocoPhillips Alaska, Inc.	5
Eni US Operating Co.	52
ExxonMobil	102
Great Bear Petroleum	0
Hilcorp	1
Kaktovik Constructors	0
Marsh Creek, LLC	0
NordAq Energy, Inc.	0
Olgoonik Development, LLC	10
Olgoonik Fairweather	4
Pioneer Natural Resources	3
Repsol E&P USA, Inc.	8
SAExploration, Inc., LLC	9
Savant Alaska, LLC	4
US Navy	2

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Overall Annual Report 2014

Number of Sightings by LOA

LOA ID	LOA Title	Company Name	Count
403	11-21	BP Exploration (Alaska)	82
404	11-22	ConocoPhillips Alaska, Inc.	3
405	11-23	Pioneer Natural Resources	3
453	12-09	Savant Alaska, LLC	4
464	12-21	ExxonMobil	1
488	12-INT-17	ExxonMobil	0
493	13-03	Brooks Range Petroleum Company	0
495	13-05	Repsol E&P USA, Inc.	0
496	13-06	Great Bear Petroleum	0
499	13-09	Pioneer Natural Resources	0
502	13-12	BP Exploration (Alaska)	0
504	13-14	Eni US Operating Co.	47
505	13-15	ConocoPhillips Alaska, Inc.	0
506	13-16	Alyeska Pipeline Service Co.	0
507	13-17	Repsol E&P USA, Inc.	0
508	13-18	SAExploration, Inc., LLC	3
509	13-19	ConocoPhillips Alaska, Inc.	0
510	13-20	ExxonMobil	88
511	13-21	ConocoPhillips Alaska, Inc.	0
512	13-22	CGG Land US, Inc.	0
517	13-INT-01	Pioneer Natural Resources	0
518	13-INT-02	BP Exploration (Alaska)	41
520	13-INT-04	Alyeska Pipeline Service Co.	2
521	13-INT-05	Brooks Range Petroleum Company	0
522	13-INT-06	Kaktovik Constructors	0
523	13-INT-07	ARCTEC Alaska	0
524	13-INT-09	Repsol E&P USA, Inc.	8
525	13-INT-09_a	US Navy	2
528	13-INT-11	Eni US Operating Co.	1
529	13-INT-12	ConocoPhillips Alaska, Inc.	0
530	13-INT-13	Repsol E&P USA, Inc.	0
531	13-INT-14	ConocoPhillips Alaska, Inc.	0
532	13-INT-15	Kaktovik Constructors	0
533	13-INT-16	ExxonMobil	9
534	13-INT-17	ConocoPhillips Alaska, Inc.	0
536	14-01	Repsol E&P USA, Inc.	0
537	14-02	SAExploration, Inc., LLC	3

538	14-03	Alaska Industrial Development and Exp	0
539	14-04	Pioneer Natural Resources	0
540	14-06	Olgoonik Development, LLC	3
541	14-07	Alaska Gasline Development Coporatio	0
542	14-08	ExxonMobil	0
543	14-09	Olgoonik Fairweather	4
544	14-10	BP Exploration (Alaska)	21
545	14-11	ExxonMobil	4
546	14-12	SAExploration, Inc., LLC	3
547	14-13	Hilcorp	1
548	14-15	NordAq Energy, Inc.	0
555	14-CS-01	Olgoonik Fairweather	0
556	14-INT-01	ARCTEC Alaska	8
557	14-INT-04	Olgoonik Development, LLC	7
558	14-INT-05	Marsh Creek, LLC	0
559	14-INT-06	BP Exploration (Alaska)	0
560	14-INT-07	Eni US Operating Co.	4
561	14-INT-08	Hilcorp	0
563	14-INT-11	NordAq Energy, Inc.	0
564	14-INT-12	ConocoPhillips Alaska, Inc.	2

Number of Sightings by Region

Region	Count
BS	352
CS	2
BSCS	0

Number of Bears Sighted: 483

Number of Bears Sighted by Company

Company Name	Count
Alaska Gasline Development Coporation	0
Alaska Industrial Development and Export Aut	0
Alyeska Pipeline Service Co.	2
ARCTEC Alaska	12
BP Exploration (Alaska)	198
Brooks Range Petroleum Company	0
CGG Land US, Inc.	0
ConocoPhillips Alaska, Inc.	6
Eni US Operating Co.	86
ExxonMobil	130

Great Bear Petroleum	0
Hilcorp	1
Kaktovik Constructors	0
Marsh Creek, LLC	0
NordAq Energy, Inc.	0
Olgoonik Development, LLC	12
Olgoonik Fairweather	5
Pioneer Natural Resources	3
Repsol E&P USA, Inc.	8
SAExploration, Inc., LLC	14
Savant Alaska, LLC	4
US Navy	2

Number of Bears Sighted by LOA

LOA ID	LOA Title	Company Name	Count
403	11-21	BP Exploration (Alaska)	113
404	11-22	ConocoPhillips Alaska, Inc.	3
405	11-23	Pioneer Natural Resources	3
453	12-09	Savant Alaska, LLC	4
464	12-21	ExxonMobil	1
488	12-INT-17	ExxonMobil	0
493	13-03	Brooks Range Petroleum Company	0
495	13-05	Repsol E&P USA, Inc.	0
496	13-06	Great Bear Petroleum	0
499	13-09	Pioneer Natural Resources	0
502	13-12	BP Exploration (Alaska)	0
504	13-14	Eni US Operating Co.	78
505	13-15	ConocoPhillips Alaska, Inc.	0
506	13-16	Alyeska Pipeline Service Co.	0
507	13-17	Repsol E&P USA, Inc.	0
508	13-18	SAExploration, Inc., LLC	4
509	13-19	ConocoPhillips Alaska, Inc.	0
510	13-20	ExxonMobil	119
511	13-21	ConocoPhillips Alaska, Inc.	0
512	13-22	CGG Land US, Inc.	0
517	13-INT-01	Pioneer Natural Resources	0
518	13-INT-02	BP Exploration (Alaska)	49
520	13-INT-04	Alyeska Pipeline Service Co.	2
521	13-INT-05	Brooks Range Petroleum Company	0
522	13-INT-06	Kaktovik Constructors	0

523	13-INT-07	ARCTEC Alaska	0
524	13-INT-09	Repsol E&P USA, Inc.	8
525	13-INT-09_a	US Navy	2
528	13-INT-11	Eni US Operating Co.	1
529	13-INT-12	ConocoPhillips Alaska, Inc.	0
530	13-INT-13	Repsol E&P USA, Inc.	0
531	13-INT-14	ConocoPhillips Alaska, Inc.	0
532	13-INT-15	Kaktovik Constructors	0
533	13-INT-16	ExxonMobil	8
534	13-INT-17	ConocoPhillips Alaska, Inc.	0
536	14-01	Repsol E&P USA, Inc.	0
537	14-02	SAExploration, Inc., LLC	7
538	14-03	Alaska Industrial Development and Exp	0
539	14-04	Pioneer Natural Resources	0
540	14-06	Olgoonik Development, LLC	3
541	14-07	Alaska Gasline Development Coporatio	0
542	14-08	ExxonMobil	0
543	14-09	Olgoonik Fairweather	5
544	14-10	BP Exploration (Alaska)	36
545	14-11	ExxonMobil	4
546	14-12	SAExploration, Inc., LLC	3
547	14-13	Hilcorp	1
548	14-15	NordAq Energy, Inc.	0
555	14-CS-01	Olgoonik Fairweather	0
556	14-INT-01	ARCTEC Alaska	12
557	14-INT-04	Olgoonik Development, LLC	9
558	14-INT-05	Marsh Creek, LLC	0
559	14-INT-06	BP Exploration (Alaska)	0
560	14-INT-07	Eni US Operating Co.	7
561	14-INT-08	Hilcorp	0
563	14-INT-11	NordAq Energy, Inc.	0
564	14-INT-12	ConocoPhillips Alaska, Inc.	3

Number of Bears Sighted by Region

Region	Count
BS	481
CS	2
BSCS	0

Number of Takes for Incidental LOAs: 34

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Number of Takes for Intentional LOAs: 52

Number of Takes by Company

Company Name	Count
Alaska Gasline Development Coporation	0
Alaska Industrial Development and Export Aut	0
Alyeska Pipeline Service Co.	1
ARCTEC Alaska	5
BP Exploration (Alaska)	51
Brooks Range Petroleum Company	0
CGG Land US, Inc.	0
ConocoPhillips Alaska, Inc.	4
Eni US Operating Co.	6
ExxonMobil	11
Great Bear Petroleum	0
Hilcorp	0
Kaktovik Constructors	0
Marsh Creek, LLC	0
NordAq Energy, Inc.	0
Olgoonik Development, LLC	4
Olgoonik Fairweather	2
Pioneer Natural Resources	1
Repsol E&P USA, Inc.	1
SAExploration, Inc., LLC	0
Savant Alaska, LLC	0
US Navy	0

Number of Takes by LOA

LOA ID	LOA Title	Company Name	Count
403	11-21	BP Exploration (Alaska)	16
404	11-22	ConocoPhillips Alaska, Inc.	1
405	11-23	Pioneer Natural Resources	1
453	12-09	Savant Alaska, LLC	0
464	12-21	ExxonMobil	0
488	12-INT-17	ExxonMobil	0
493	13-03	Brooks Range Petroleum Company	0
495	13-05	Repsol E&P USA, Inc.	0
496	13-06	Great Bear Petroleum	0
499	13-09	Pioneer Natural Resources	0
502	13-12	BP Exploration (Alaska)	0
504	13-14	Eni US Operating Co.	5

505	13-15	ConocoPhillips Alaska, Inc.	0
506	13-16	Alyeska Pipeline Service Co.	0
507	13-17	Repsol E&P USA, Inc.	0
508	13-18	SAExploration, Inc., LLC	0
509	13-19	ConocoPhillips Alaska, Inc.	0
510	13-20	ExxonMobil	3
511	13-21	ConocoPhillips Alaska, Inc.	0
512	13-22	CGG Land US, Inc.	0
517	13-INT-01	Pioneer Natural Resources	0
518	13-INT-02	BP Exploration (Alaska)	30
520	13-INT-04	Alyeska Pipeline Service Co.	1
521	13-INT-05	Brooks Range Petroleum Company	0
522	13-INT-06	Kaktovik Constructors	0
523	13-INT-07	ARCTEC Alaska	0
524	13-INT-09	Repsol E&P USA, Inc.	1
525	13-INT-09_a	US Navy	0
528	13-INT-11	Eni US Operating Co.	1
529	13-INT-12	ConocoPhillips Alaska, Inc.	0
530	13-INT-13	Repsol E&P USA, Inc.	0
531	13-INT-14	ConocoPhillips Alaska, Inc.	0
532	13-INT-15	Kaktovik Constructors	0
533	13-INT-16	ExxonMobil	8
534	13-INT-17	ConocoPhillips Alaska, Inc.	0
536	14-01	Repsol E&P USA, Inc.	0
537	14-02	SAExploration, Inc., LLC	0
538	14-03	Alaska Industrial Development and Exp	0
539	14-04	Pioneer Natural Resources	0
540	14-06	Olgoonik Development, LLC	1
541	14-07	Alaska Gasline Development Coporatio	0
542	14-08	ExxonMobil	0
543	14-09	Olgoonik Fairweather	2
544	14-10	BP Exploration (Alaska)	5
545	14-11	ExxonMobil	0
546	14-12	SAExploration, Inc., LLC	0
547	14-13	Hilcorp	0
548	14-15	NordAq Energy, Inc.	0
555	14-CS-01	Olgoonik Fairweather	0
556	14-INT-01	ARCTEC Alaska	5
557	14-INT-04	Olgoonik Development, LLC	3

558	14-INT-05	Marsh Creek, LLC	0
559	14-INT-06	BP Exploration (Alaska)	0
560	14-INT-07	Eni US Operating Co.	0
561	14-INT-08	Hilcorp	0
563	14-INT-11	NordAq Energy, Inc.	0
564	14-INT-12	ConocoPhillips Alaska, Inc.	3

Number of Takes by Region

Region	Count
BS	85
CS	1
BSCS	0

Number of Bears Hazed: 67

Number of Bears Hazed by Company

Company Name	Count
Alaska Gasline Development Coporation	0
Alaska Industrial Development and Export Aut	0
Alyeska Pipeline Service Co.	1
ARCTEC Alaska	1
BP Exploration (Alaska)	43
Brooks Range Petroleum Company	0
CGG Land US, Inc.	0
ConocoPhillips Alaska, Inc.	3
Eni US Operating Co.	3
ExxonMobil	11
Great Bear Petroleum	0
Hilcorp	0
Kaktovik Constructors	0
Marsh Creek, LLC	0
NordAq Energy, Inc.	0
Olgoonik Development, LLC	3
Olgoonik Fairweather	0
Pioneer Natural Resources	1
Repsol E&P USA, Inc.	1
SAExploration, Inc., LLC	0
Savant Alaska, LLC	0
US Navy	0

Number of Bears Hazed by Intentional LOA

LOA ID	LOA Title	Company Name	Count
488	12-INT-17	ExxonMobil	0

517	13-INT-01	Pioneer Natural Resources	0
518	13-INT-02	BP Exploration (Alaska)	30
520	13-INT-04	Alyeska Pipeline Service Co.	1
521	13-INT-05	Brooks Range Petroleum Company	0
522	13-INT-06	Kaktovik Constructors	0
523	13-INT-07	ARCTEC Alaska	0
524	13-INT-09	Repsol E&P USA, Inc.	1
525	13-INT-09_a	US Navy	0
528	13-INT-11	Eni US Operating Co.	1
529	13-INT-12	ConocoPhillips Alaska, Inc.	0
530	13-INT-13	Repsol E&P USA, Inc.	0
531	13-INT-14	ConocoPhillips Alaska, Inc.	0
532	13-INT-15	Kaktovik Constructors	0
533	13-INT-16	ExxonMobil	8
534	13-INT-17	ConocoPhillips Alaska, Inc.	0
556	14-INT-01	ARCTEC Alaska	1
557	14-INT-04	Olgoonik Development, LLC	3
558	14-INT-05	Marsh Creek, LLC	0
559	14-INT-06	BP Exploration (Alaska)	0
560	14-INT-07	Eni US Operating Co.	0
561	14-INT-08	Hilcorp	0
563	14-INT-11	NordAq Energy, Inc.	0
564	14-INT-12	ConocoPhillips Alaska, Inc.	3

Number of Bears Hazed by Region

Region	Count
BS	66
CS	1
BSCS	0

Number of Bears Hazed by Deterrent Type

Deterrent Type	Count	Percent
	6	9
Air horn	6	9
Bear alarm	1	1.5
Horn	35	52.2
Light	18	26.9
Other	5	7.5
Siren	13	19.4

12.0 APPENDIX III: CAPTURE-BASED RESEARCH IN THE CHUKCHI SEA

This appendix describes activities under IAA M09PG00024 related to physical-capture research of the CS subpopulation, including expansion of sampling efforts to areas north of the Lisburne Peninsula. The goal of this sampling expansion was to provide updated information on delineation of the SB and CS subpopulations as necessary to identify potential impacts of human activities in the Chukchi Sea Planning Area (CSPA) for oil and gas.

12.1 Summary

Accurate scientific information is needed for management and conservation of the Alaska-Chukotka (AC) population of polar bears (*Ursus maritimus*). The AC population (also referred to as the "Chukchi Sea" [CS] subpopulation) inhabits the Bering, Chukchi, and eastern Siberian seas, located west of Alaska. Conservation challenges include sea-ice loss due to climate change, likely future oil and gas exploration and development, increasing human activity in a warming Arctic, and identifying a sustainable rate of subsistence harvest.

The USFWS and collaborators began research on the AC population in 2008. Focal areas include nutritional condition, health, and feeding ecology; distribution and habitat use; and population dynamics (e.g., reproductive and survival rates).

Spring 2016 marked the 7th year of fieldwork for this project:

- We captured, collected information from, and released 71 polar bears on the sea ice between the communities of Point Hope and Shishmaref, during the period 21 March to 26 April 2016. We obtained genetic samples using biopsy darts for five polar bears that could not be captured for logistical reasons.

- We expanded geographic sampling to north of the Lisburne Peninsula by using the Cape Lisburne Long Range Radar Site (LRRS) as a fuel depot, with support from the U.S. Air Force (USAF), BOEM, and others. The goal was to increase sampling of bears that may use habitats in the Chukchi Sea 193 Lease Sale Area. Open water and poor ice conditions limited our ability to work north of the Lisburne Peninsula.
- 15 of the captured bears had been previously tagged in the CS region during the period 2008-2015. Four of these recaptures were located by telemetry via radiocollars that were applied in 2015.
- We deployed 14 Global Positioning System (GPS) and 3 ARGOS satellite radiocollars on adult females, which will drop off after one year. We also deployed 8 small ear-mounted satellite tags, 4 small glue-on satellite tags, and 15 geolocation tags.
- The capture sample included 5 single adult females, 19 adult females with dependent young, 14 adult males, 4 subadults (some of which may have been independent two-year-olds), 12 dependent two-year-olds (C2s), 17 yearlings (C1s), and 0 cubs-of-the-year (C0s).
- On 30 March 2016 we sighted an adult female with one live C0 and one recently-dead C0, on the sea ice approximately 55 mi northwest of Shishmaref. It is likely that this female gave birth in a den on the ice. These bears were not captured because ambient temperatures were low and the C0 was small.
- On average, adult males weighed nearly twice as much as adult females (1029 lb and 528 lb, respectively), which is typical of polar bears. We captured three adult males over 1200 lb. One of these bears was an 18-year-old male weighing 1405 lb, which is a new record for spring polar bear studies in the U.S.

- A study describing changes in polar bear land use and sea-ice conditions in the CS region was recently published (Rode et al. 2015). Several other analyses are in preparation, including assessments of current vs. historic habitat use, and an initial assessment of population status.
- Similar to observations in previous years and published findings (Wilson et al. 2014), research in 2016 indicated that the offshore area between Point Hope and Shishmaref is important habitat for the AC polar bear population. USFWS and collaborators plan to continue this project in 2017 subject to funding availability.

12.2 Background

The AC polar bear population inhabits the Bering, Chukchi, and eastern Siberian seas, and moves between the U.S. and Russia. Although there are some differences in the management boundaries, the AC population largely overlaps the CS subpopulation, which is one of 19 polar bear subpopulations recognized by the Polar Bear Specialist Group (PBSG) of the International Union for the Conservation of Nature (IUCN). Sea-ice loss due to climate change has been identified as the primary threat to the AC population and to polar bears throughout their range (USFWS 2015). Loss of preferred sea-ice habitats has the potential to reduce bears' access to their primary prey, ice seals, and increase interactions with humans during longer ice-free seasons. On the basis of this primary threat, polar bears were listed as "threatened" under the U.S. Endangered Species Act (ESA) in 2008. Scientific information suggests that two of the 19 polar bear subpopulations have exhibited a negative response to sea-ice loss; that several others are either productive, stable, or exhibiting early signs of stress; and that data are insufficient to determine population status for many subpopulations (see the PBSG Status Table <http://pbsg.npolar.no/en/status/status-table.html>). The polar bear was recently categorized as "vulnerable" by the IUCN Red List Authority (Wiig et al. 2015), a designation which is has held for most years since 1982. Variability in the current status of polar bears—along with forecasts of continued sea-ice loss—highlights the importance of understanding the ecological status of individual subpopulations when assessing threats and persistence for the species.

In addition to anthropogenic climate change, the AC population faces near-term management issues and potential threats. Reduced summer sea ice is allowing increased human access to the Arctic, opening new shipping routes and potentially facilitating the extraction of oil and gas reserves. There are several hundred oil and gas leases in the U.S. portion of the CS region, none of which are currently being developed; six exploration wells have been drilled since the early 1990s and exploration may resume in future years. Potential effects of industrial development on polar bears include disturbance, alteration of physical habitat and prey distribution, and risk of exposure to oil spills. Additionally, polar bears in the CS region represent an important traditional, cultural, and nutritional resource for Native people in Alaska and Chukotka. Annual decisions on sustainable subsistence harvest levels are made by the Commissioners of the *Agreement between the Government of the United States of America and the Government of the Russian Federation on the Conservation and Management of the Alaska-Chukotka Polar Bear Population* (U.S.-Russia Agreement), an international treaty signed in 2000. In the U.S. portion of the CS region, subsistence harvest is legal and monitored under the MMPA. Sustainable harvest limits were identified under the U.S.-Russia Agreement in 2010, and are planned to be implemented in a phased manner through a co-management approach.

Accurate and up-to-date scientific information on the AC population is required to address the conservation and management challenges listed above and to fulfill requirements of the ESA, MMPA, National Environmental Policy Act (NEPA), U.S.-Russia Agreement, and the

1973 Agreement on the Conservation of Polar Bears. To fill this information need, the USFWS in collaboration with the U.S. Geological Survey (USGS) and partners initiated a capture-based research program in 2008. During the years 2008-2011, 2013, and 2015-2016; polar bears have been captured and studied on the sea ice off the coast of western Alaska. Initial findings have been used to understand contemporary distribution and habitat use of the AC subpopulation, including the overlap of polar bear habitats and areas planned for oil and gas exploration (Wilson et al. 2014). The initial four years of data (2008-2011) provided an assessment of the population's ecology (Rode et al. 2014a), suggesting that sea-ice loss through 2011 did not have negative effects on physical stature, body condition, and reproduction compared to research conducted 1986-1994 in the CS region; and that the AC population is currently more productive than the Southern Beaufort Sea subpopulation that occurs north of Alaska. However, Rode et al. (2015) recently found that the proportion of the AC population spending the summer on land has nearly doubled, and that bears are spending 30 days longer on land, compared to the period 1986-1995. Increased land use may decrease the ability of polar bears to access ice seals, resulting in nutritional stress and population declines.

Multiple years of data are required to understand the status of the AC population because: (1) annual sample sizes are relatively small because the population is widely dispersed, making bears logistically difficult to locate and capture (this is a particular challenge for estimating population size); (2) there is a large amount of variability in the Arctic environment requiring long-term data to identify trends; (3) polar bears have a long life span; and (4) robust relationships between ecological and demographic measures and changes in sea ice are necessary to infer the effects of future declines in sea-ice extent. USFWS and collaborators are currently preparing an initial assessment of population status, including estimation of abundance and vital rates (e.g., recruitment, survival). Looking forward, the USFWS, USGS, and an expanding group of collaborators and partners will continue analyzing the data obtained from this research, and plan to continue fieldwork in 2017 subject to funding availability.

12.3 Fieldwork methods

Polar bears were captured and released on the sea ice west of Alaska between the Seward and Lisburne peninsulas. A Cessna 185 fixed-wing aircraft equipped with skis and an AStar 350 helicopter were used to search for bears. We also used the fixed-wing to haul jet fuel to the helicopter on the sea ice. The helicopter was based at the Red Dog Mine port facility located on the coast approximately 12 miles south of Kivalina, and the fixed wing was based at USFWS facilities operated by the Selawik National Wildlife Refuge (NWR) in Kotzebue. Additional fuel was cached at the Cape Lisburne LRRS.

When a polar bear was sighted and it was safe to proceed, we sedated it with the drug Telazol® using a dart fired from the back seat of the helicopter. To obtain a representative sample we captured all bears that were sighted, when it was safe to do so. Sedated bears were tattooed with a unique identification number on the inside of the upper lip, and fitted with small plastic ear tags stamped with the same number. These marks allow monitoring the history of individual bears over time. We measured body length, skull size, chest girth, and body mass for each bear (Fig 1). Small amounts of blood and hair were collected to evaluate diet, disease, and contaminant levels. A vestigial premolar (a small, unused tooth) was extracted to determine age by counting growth rings. A fat biopsy was taken to assess nutritional condition (i.e., fatness) and diet using fatty acid analysis. For some adult females, bioelectrical impedance analysis was used to determine body composition. Some bathroom scales use a similar non-invasive technology to estimate body fat in people. We used fur dye to mark a number on the backs of captured bears so they could be identified from the air—and therefore not recaptured—in the same year. The numbers will disappear in summer when the bears molt.

Figure 1. Using a tripod and chain hoist to weigh a sedated polar bear. Sedated bears begin to wake up after 30-60 minutes, and resume near-normal activity and movement rates after 2-3 days.

Adult female bears were fitted with GPS satellite radiocollars, which were applied by sliding them over the bear's head. While most bears retain their collars, a few will slide them off after waking up. Radiocollars provide year-round movement on habitat use and potential responses to sea-ice loss. Data from radiocollars also show population boundaries (e.g., that individual bears often move between the U.S. and Russia) and how polar bears react to human activities. We do not fit radiocollars to young bears because they are still growing, or to adult males because their necks are larger than their heads and the collars would slip off. Each collar was equipped with two automatic release devices programmed to drop it off after one year (Fig. 2). We also deployed prototype ear-mounted satellite tags on some bears (Fig. 2). We continue to work with telemetry companies to develop these smaller tags because they are less cumbersome and can potentially provide movement data for subadult and male bears. Finally, in 2016 we deployed nickel-sized geolocation tags that were molded to the plastic ear tags used to individually mark bears. The geolocation tags record light levels and, if recovered when a bear is recaptured, may indicate patterns in habitat use and denning activity.

Figure 2. Satellite radiocollars (left panel) are applied to some adult female polar bears. The two black boxes are automatic release devices that ensure collars will drop off after one year. Ear-mounted satellite tags (right panel) are being developed as a less-cumbersome method of collecting movement data on polar bears.

Polar bears are difficult to study because they occur at low densities in remote areas. Using aircraft to access their habitat and physically capture a limited number of bears is a standard scientific method used throughout the Arctic. We continue to improve the methods developed over the years to ensure each animal's safe handling and maximize the information collected. Although there is risk during the live capture of any wild animal (e.g., mortality rates for many brown bear studies approach 1%), no polar bears have been injured or killed in 420 captures during USFWS polar bear studies in the CS region from 2008-2016. We monitor the body temperature, respiration rate, and drug response of all sedated bears. Following capture, we attempt to check on bears later in the day or on the next day. We have also been monitoring any potential effects of capture, and recently published a study showing that bears recover normal activity and movement patterns with 2-3 days post-capture with no apparent effects on individual health, reproduction, or cub growth or survival (Rode et al. 2014b). Since 2015, CS polar bear research has been conducted under the supervision of a veterinarian who also participates in fieldwork. Study protocols are approved by the USFWS Region 7 Institutional Animal Care and Use Committee under permit 2016-001, and under the ESA and MMPA permit MA046081-4 issued by the USFWS Division of Management Authority.

12.4 Description of 2016 fieldwork

We flew 28 days during the period 21 March to 26 April, 2016. Polar bears were captured on the sea ice up to 125 miles from the Red Dog Mine port facility (Fig. 3a). Similar to previous years, the distribution of bears was patchy and variable during the field season, and the areas that we could access were determined largely by weather, sea-ice conditions, and aircraft range. We attempted not to fly within 30 miles of Point Hope, or within 10 miles of Kivalina, to avoid potential disturbance during spring whaling. We worked north of the Lisburne Peninsula on 27 March and 16 April. Although we monitored sea-ice conditions throughout the field season, an abnormally large and persistent area of open water and thin ice north of the Lisburne Peninsula limited our ability to work there (Fig. 3b).

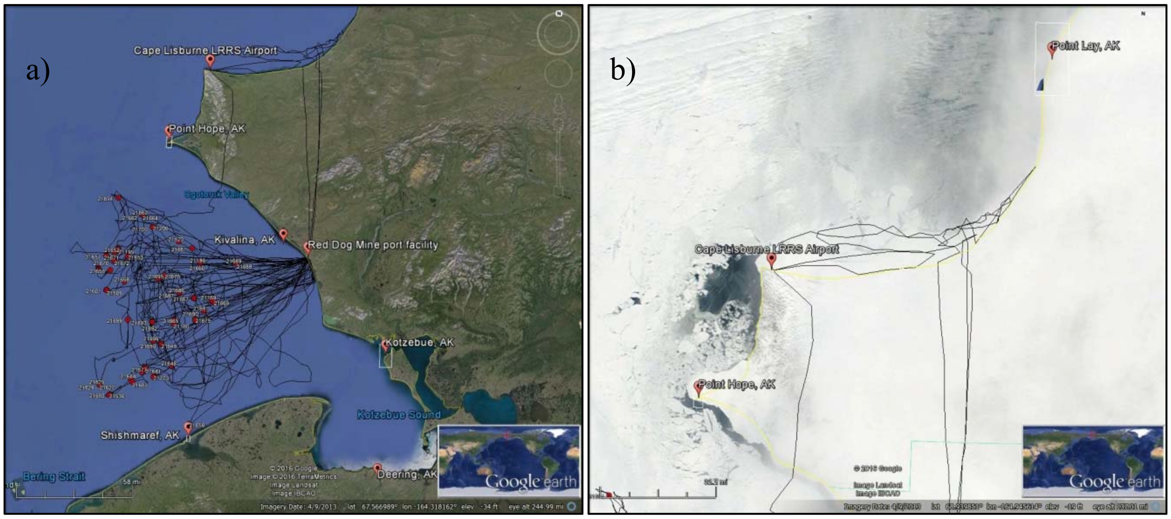

Figure 3. Panel a) area of polar bear research in the Chukchi Sea, west of Alaska. Track log of the helicopter (black lines) and locations of captured polar bears (red dots with bear identification numbers) are shown for 2016 fieldwork. Panel b) MODIS satellite imagery showing sea-ice conditions north of the Lisburne Peninsula on 10 April 2016. Grey areas, which represent thin ice and open water, were unsafe to fly over and therefore helicopter search effort (black lines) was limited to a near-shore strip of thicker ice.

We captured and released 71 polar bears. Twenty-three of these bears were initially spotted by the fixed wing. Previous sample sizes for this project were 35, 39, 69, 77, 68, and 61 for 2008-2011, 2013 and 2015, respectively. We biopsy darted but did not capture five bears due to weather, ice, and fuel limitations. Of the 71 bears captured, 15 had been previously captured and marked during this study 2008- 2015 (four of these recaptures were located by radiotelemetry and do not represent random sampling). The sex and age composition of the capture sample included a lower proportion of subadults, and a higher proportion of adult females with dependent young, compared to previous years (Table 1). An analysis of the data will be necessary to determine the potential significance of interannual variation in sex and age composition as a function of sampling and biological factors. We did not capture any C0 in 2016, although an adult female and one live C0 were observed on the sea ice as stated in the Summary. The low representation of new family groups is consistent with information suggesting that most females in the AC population den on Wrangel or Herald islands, or on the coastline of Chukotka, and therefore are less likely to occur in our study area during spring fieldwork.

Year	Cub-of-the-year	Yearling	Two-year-old	Subadult*	Adult** female (single)	Adult female (with young)	Adult male
2008	0	4	1	7	6	4	13
2009	0	1	3	8	6	3	18
2010	0	21	4	8	5	14	17
2011	2	8	16	17	3	15	16
2013	2	9	4	10	9	8	26
2015	0	8	5	8	9	7	24
2016	0	17	12	4	5	19	14

Table 1. Sex, field-estimated age class, and reproductive status of polar bears captured in the Chukchi Sea region during U.S. Fish and Wildlife Service research in 2008-2011, 2013, 2015, and 2016. Some bears that were field-estimated to be subadults may have been two-year-olds that had recently become independent of their mothers; ages will be confirmed by laboratory analysis of vestigial premolars. *Subadults were field-estimated to be 3-4 years. **Adults were field-estimated to be ≥5 years.

We deployed 17 GPS radiocollars on adult females, 14 with Iridium transmission and 3 with Argos transmission, manufactured by Telonics Inc. All collars will drop off after one year by double automatic release devices (Figure 2). We also deployed 8 ear-mounted satellite tags manufactured by Sirtrack and four glue-on tags manufactured by Wildlife Computers on subadult and male bears. Finally, we deployed 15 geolocation tags manufactured by Migrate Technology on independent bears of both sexes.

On average, adult males captured in 2016 weighed nearly twice as much as adult females, which is typical of polar bears (Table 2). Three adult males over 1200 lb were captured and the largest adult male weighed 1405 lb. To our knowledge this is the largest polar bear that has been weighed and released into the wild during spring research in the U.S. This bear was an 18-year-old male that had been previously captured in 2010, 2013, and 2015. Due to the low recapture rates during CS research, only five of the 356 unique bears included in this study have been captured four or more times during the period 2008-2016.

Subjectively, the body condition of captured adult polar bears appeared similar to previous years. Using a body condition index that ranges from 1-5 for independent bears, with 1 being skinny and 5 being very fat, we classified 6 adults as index 2 (thin), 30 bears as index 3 (average), and 1 bears as index 4 (fat). Body condition indices likely reflect a combination of factors including general nutritional condition, capture date (e.g., most bears get fatter as the spring progresses), and sex and age composition (e.g., it is normal for young males to be thin).

Sex	Age class	Mean weight (lb)	Maximum weight (lb)	Sample size
Female	Adult	528	650	24
Male	Adult	1029	1405	14
Female	Subadult	NA	NA	NA
Male	Subadult	482	526	4
Female	Two-year-old	347	386	5
Male	Two-year-old	436	510	7
Female	Yearling	235	304	6
Male	Yearling	262	332	11
Female	Cub-of-the-year	NA	NA	NA
Male	Cub-of-the-year	NA	NA	NA

Table 2. Scale weights of polar bears captured in the Chukchi Sea region during U.S. Fish and Wildlife Service research in 2016. *Subadults were field-estimated to be 3-4 years. **Adults were field-estimated to be ≥5 years.

In spring 2012, the USGS polar bear program observed an unusually high rate of an alopecia syndrome (i.e., hair loss and skin lesions) during research in the southern Beaufort Sea. A similar condition had been observed in polar bears, at a lower frequency, in previous years of research in both the Beaufort and CS regions. During fieldwork in 2016, 14 of 71 captured bears exhibited hair loss or lesions, most of which appeared minor or healed.

In 2016, ice conditions were suitable for working in a large portion of the study area, despite the fact that 2016 marked a record-low winter sea-ice extent throughout the Arctic (see details at <http://earthobservatory.nasa.gov/IOTD/view.php?id=87831>). As noted previously, the large polynya north of the Lisburne Peninsula precluded most work in that area. During research flights, approximately 912 ringed seals and 740 bearded seals were observed within roughly 0.5 miles of the helicopter. The number and species of seals sighted has varied among years; it is unknown whether differences are due to observational variation, sighting bias (e.g., ringed seals don't like to haul out on cold windy days), changes in seal distribution and numbers within the study area, or other factors.

Similar to previous years, we performed outreach and maintained contact with local communities and organizations. We worked with the communities of Point Hope and Kivalina to identify no-fly zones and ensure that our research did not overlap with subsistence activities, including daily calls to the City of Kivalina. We appreciate the input from hunters. At the end of the season, we discussed this year's observations at the Red Dog Mine and the National Park Service Northwest Arctic Heritage Center in Kotzebue. We will continue outreach in other communities in conjunction with partners. We hope to continue learning about observations by people living in polar bear country.

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