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Northern Sea Otter (*Enhydra lutris*) Abundance and Distribution on the Kodiak Archipelago, Alaska

McCrea Cobb

Photo: Robin Corcoran/USFWS

Kodiak National Wildlife Refuge

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Keywords: aerial survey, Alaska, Bodkin-Udevitz, *Enhydra lutris*, Kodiak, sea otter

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Northern Sea Otter (*Enhydra lutris*) Abundance and Distribution on the Kodiak Archipelago, Alaska

McCrea Cobb[1]

Abstract

Northern sea otter (*Enhydra lutris*) abundances in the Aleutian Islands and southern Alaska Peninsula regions of Alaska have declined by approximately 90% since the 1980s. As a result, the southwestern Alaska distinct population segment, which ranges from the Aleutian Islands to Lower Cook Inlet and includes the Kodiak Archipelago, was listed as threatened under the Endangered Species Act. The status of sea otters in the Kodiak area was unclear because the population had not been surveyed since 2004. To update our understanding of population trend, we surveyed sea otter abundances in 2014 using the same method applied in three previous surveys (Bodkin-Udevitz). We estimated 13,274 (SE = 1,885) sea otters. Densities were highest in straights between Kodiak, Raspberry and Afognak Islands and bays along western Kodiak Island. In contrast, sea otters were notably absent from much area along eastern Kodiak Island. Evaluation of population trend indicated that sea otters in Kodiak have rebounded in abundances after a notable decline from 1989 to 2001.

Introduction

The northern sea otter is a keystone species in the nearshore marine environment. Significant declines in sea otter abundance can produce ecosystem level changes (Estes and Palmisano 1974). In the 1990s, sea otters in south central Alaska declined in abundance, which led to this distinct population segment being listed as threatened under the Endangered Species Act (ESA, as amended 1978). However, rates of declines varied across the population segment. In the Kodiak Archipelago, abundances declined approximately 56% between 1989 and 2001 at an estimated rate of 6.7% per year (Degange et al. 1995), yet by 2004 had returned to 1989 abundances (unpublished data). Reasons for this variation in trend in the Kodiak area are unknown.

The Kodiak Archipelago historically supported an abundant sea otter population, as evidenced by early hunting records and archeological midden sites (Lensink 1962). Heavy hunting pressure from the mid-1700s to the early 1900s reduced the population to a single remnant colony near Latex Rocks, vicinity of northern Shuyak Island. Although early survey data are sparse, the population appears to have increased from a few hundred to several thousand sea otters between the 1950s and 1980s (Lensink 1962). Radio telemetry studies in the 1980s reported high adult survival rates (89-96%) and high weaning success at the leading edge of the population expansion near Kodiak Island and found abundant food resources and continued population growth (Monson and Degange 1995). Additionally, this population had an estimated population

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growth rate of 10% per year through the late 1980s, which was expected to continue as animals expanded into unoccupied suitable habitats (Bodkin et al. 1999). However, despite ample unoccupied habitat along eastern and southern end of Kodiak, the population appears to have stabilized since 1989, which suggests that population growth has been constrained by the presence of unidentified density dependent factors (Doroff et al unpublished report). An updated estimate was needed to determine the current status and trend of the population.

Various methods have been used to assess sea otter abundances in the Kodiak area. Sea otter minimum counts were first conducted at Kodiak in 1975 and 1976 using a combination of helicopter-based transect surveys, and skiff and shore-based counts (Schneider 1976). Results suggested that the primary range was limited to the northern area of archipelago, from Shuyak Island west to Raspberry Island and south to Marmot Island. A fixed-wing minimum count in 1984 indicated that the population had grown 49%, densities had shifted spatially, and range had expanded. A helicopter-based survey conducted in 1989 to assess loss associated with the Exxon Valdez oil spill produced the first reliable estimate of sea otters adjusted for detection (Degange et al. 1995). This survey provided a baseline population abundance estimate (13,526 sea otters, SE = 1,199) at the onset of the period of regional decline in sea otter in southwestern Alaska (Doroff et al. 2003). Subsequent fixed-wing aerial surveys conducted in 1994, 2001 and 2004 that applied a method developed by Bodkin and Udevitz (1999) showed the population had rebounded to 1989 abundances (Doroff unpublished report).

Given a lack of observed exponential growth, unknown factors have apparently limited the rate of population growth of sea otters in the Kodiak area. Predation can be a potential limiting factor for sea otters. Estes et al. (1998) concluded that adult mortality from to orca (*Orcinus orca*) predation was the primary cause of a rapid decline in sea otters in the Aleutian Islands (Estes et al. 1998). Conversely, at Kodiak, abundant food resources and relatively sheltered pupping areas contributed to high adult and pup survival rates during the same period (Doroff and Degange 1994, Monson and Degange 1995). Emigration from Kodiak to adjacent areas could be having a dampening effect on population growth, but we have no data on sea otter movement patterns in the region. Mortality and decreased habitat availability could be caused by paralytic shellfish poisoning (DeGange and Vacca 1989), but sea otters have been shown to actively avoid shellfish with high toxin levels (Kvitek et al. 1991). Unreported harvest may be suppressing population growth in some localities, particularly those proximate to human development. Diseases, such as phocine distemper, could be having a population-level impact (Goldstein et al. 2009).

Quantifying sea otter population abundances over large regions with inclement weather, such as southwestern Alaska, is a challenge. Boat-based surveys offer observers the advantage of higher rates of detecting sea otters, but this approach is generally limited to smaller study areas. Helicopters provide a platform that maximizes detection and can cover a large region, but high costs generally prohibit its use as a long-term monitoring tool. Fixed wing aircraft-based surveys allow observers to cover a large region at a comparably lower cost, but detection rates are compromised. To address this shortcoming, Bodkin and Udevitz (1999) developed fixed wing aerial survey protocol that combines counts of otters within strip transects over a large area with intensive surveys of a fraction of the area to provide data on detection rates. The 2014 survey applied this method because it had been successfully implemented in the Kodiak area (unpublished data 2004).

To better understand population status and make scientifically-informed conservation management decisions, empirical data on sea otter abundances is needed to assess trends over time. Our survey objective was to produce an updated estimate of sea otter abundance, with statistical confidence, for the Kodiak Archipelago following the Bodkin-Udevitz survey protocol.

Study Area

The study area (8,475 km^2) was a region surrounding Kodiak Archipelago, Alaska, from waterline to 2-km offshore or 100-m depth, whichever was greater (Figure 1). The study area encompassed typical near- and off-shore sea otter habitat, as described by previous sea otter surveys (Schneider 1976, Simon-Jackson et al. 1985) and studies on the Kodiak Archipelago (Monson and Degange 1995).

The Kodiak Archipelago is located in the western Gulf of Alaska, separated 40-65 km from mainland Alaska by the Shelikof Straight. The Albatross Bank, a broad expanse of shallow water, borders the eastern side of the archipelago in the Gulf of Alaska. The region is characterized by strong tidal currents, and shallow (<15 m) waters with semi-protected soft-sediment habitats of sand and gravel substrate. In areas that have historically held high sea otter densities, including Afognak Straight and Bay, shallow waters also contain exposed rock and shell litter and support extensive bull kelp (*Nereocystis luetkeana*) beds (Monson and Degange 1995).

Methods

We counted sea otters using an aerial survey protocol developed by Bodkin and Udevitz (1999) and previously implemented in the Kodiak area in 1994, 2001 and 2004 (U.S. Fish and Wildlife Service 2010). Additionally, we applied Bodkin's (2011) detailed standard operating procedures for the method. Prior to conducting the survey, the observer (MC) completed training in the survey protocol at Prince William Sound, during which surveys were repeatedly conducted until the observer achieved a minimum detection rate of 90%, as assessed by concurrent observations by boat-based observers.

We conducted surveys from an American Champion Scout (a high-wing, single-engine aircraft with tandem seating) on floats. Per protocol, the pilot attempted to fly at 92 m (300 ft) above sea-level (ASL) and maintain an airspeed of 117 kph (72 mph).

To allocate survey effort in proportion to expected sea otter abundance and to maximize efficiency, we divided the study area into high and low density strata. The high density stratum (4,787 km^2) extended from shoreline to 400 m seaward, or to the 40 m depth contour, whichever was greatest. The low density stratum (3,688 km^2) began at the seaward high density stratum boundary and extended 2 km offshore, or to the 100 m depth contour, whichever was greater. For safety reasons, we restricted the low density stratum to within 12 km of shore, which excluded some potential sea otter habitats along the eastern and southern sides of Kodiak Island. Bays and inlets less than 6 km wide were included in the high density stratum regardless of water depth (Bodkin and Udevitz 1993).

The sampling unit was a 400 m-wide strip transect oriented perpendicular to the coastline. Adjacent transects were parallel and separated by 2 km in the high density stratum and by 8 km in the low density stratum.

We replicated all strip transects previously surveyed in 2004, and we included additional transects along the southern and eastern sides of Kodiak Island to assess abundances in these previously unsurveyed regions. We replicated higher density survey transects, which included areas of northern Kodiak Island, Raspberry Island, and western Kodiak Island. The remaining transects were surveyed once.

To estimate the number of sea otters present on the transect strips but not observed, we developed survey-specific correction factors by conducting intensive search units (ISU) (Bodkin and Udevitz 1999). An ISU consisted of five concentric 400-m diameter circles flown within the strip transect. We initiated an ISU when we observed one or more sea otters ("initiating group") more than a minute after a previous ISU was completed. For each ISU, we recorded the number and age class (adult or pup) of sea otters detected on the initial count (the first quarter turn of the ISU) and during the ISU itself (after the first quarter turn of the ISU). Sea otters counted during the initiating group (first group sighted in the initial count) and those that entered an ISU during the course of surveying an ISU, were not included in the calculation of the correction factor. We photographed large (≥25) sea otter groups and then later quantified their sizes by examining photos on a desktop computer. Count data were georeferenced and digitized in real-time using a laptop computer (Panasonic ToughBook CF31) connected to a GPS unit (Garmin Glo, Garmin USA, Olathe, KS) via Bluetooth and running a custom ArcPad (ESRI 2012) application (FWS Marine Mammals Management, Anchorage, AK).

We applied the mean correction factors calculated from ISU's with ≥2 groups of sea otters (the initiating group was not used in the calculation of the correction factor) to adjust our estimates of abundance for detection. We considered ISU counts and photographed groups as complete counts and therefore excluded them from a correction factor adjustment. We estimated detection rates separately for each replicate. Our estimate of variance in the adjusted population estimate included variance associated with sea otter density among transects and variance of the correction factor calculated from the ISUs. We conducted statistical analyses in SAS (SAS Institute, Cary, NC).

Results

We completed 729 transects (657 transects in high density and 72 transects in low density strata) over 20 days between 2 July and 1 August, 2014. Weather conditions during the survey period were ideal: 19 of 31 days in July were dry with light winds and little to no fog. We limited daily surveys to the period between 08:00 and 16:00 hrs.

Transects totaled 2,906 km, which included 2,424 km in the high density stratum and 482 km in the low density stratum. Transect strip area totaled 8,484 km^2, which included 4,787 km^2 in the

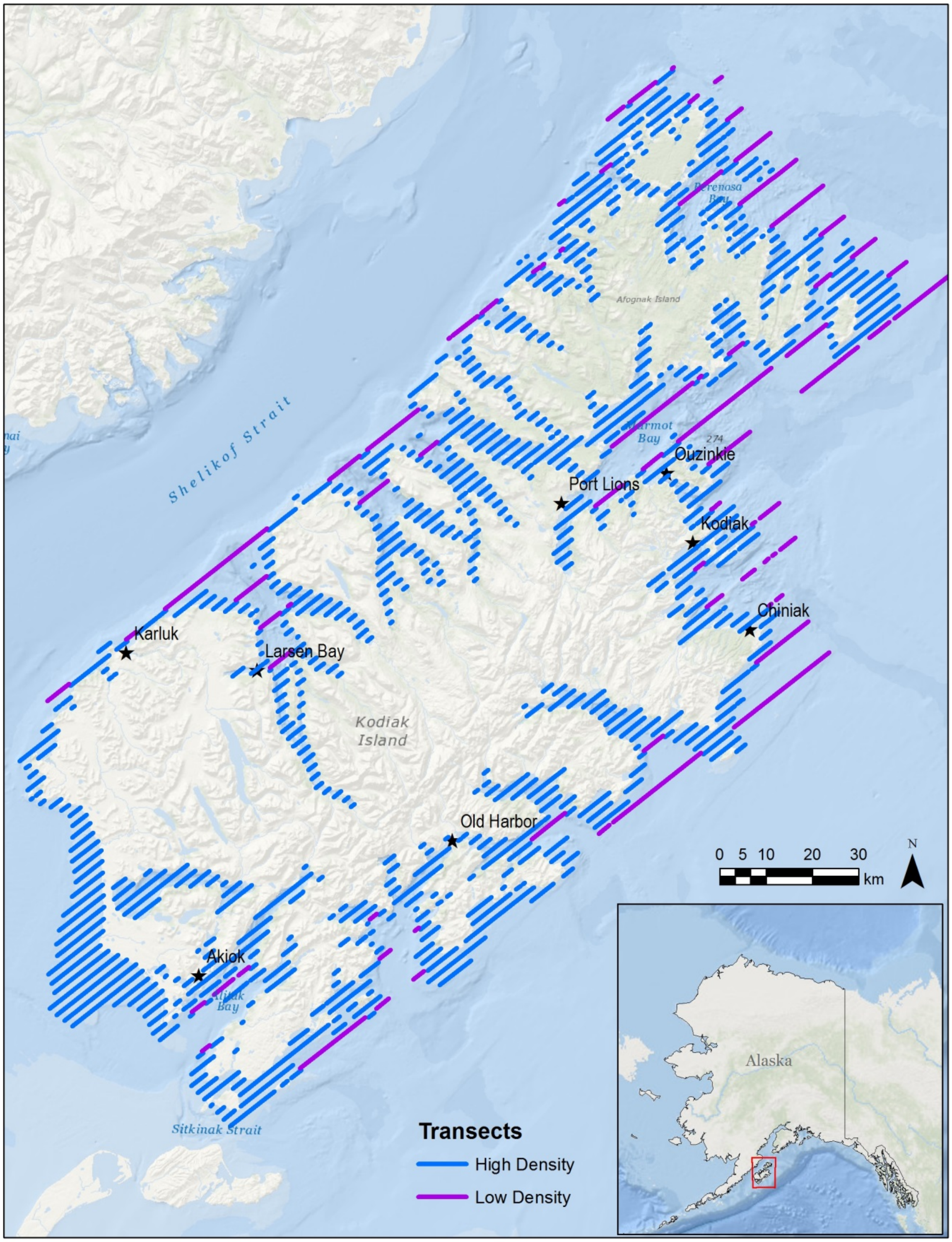

Figure 1. Map of sea otter survey transects, Kodiak Archipelago, Alaska, 2014.

high density stratum and 3,698 km^2 in the low density stratum. We completed one replicate of all transects and a second replicate of a subset of high density stratum transects (175 of 729, or 24% of transects) to the north of Kodiak Island, and to south of Raspberry and Afognak Islands.

We completed 92 ISUs to estimate corrections factors (Table 1). The mean correction factor varied among replicates from 1.51 (SE = 0.11) to 2.97 (0.94).

We counted a total of 3,609 sea otters in 1,366 groups. After correcting for sightability and extrapolating to the study area, we estimated a total of 13,274 sea otters (SE = 1,885.04) or 1.56 sea otters/km^2 (Table 2). This included 12,167 sea otters (SE = 1,806.63) in the high density stratum (2.54 sea otters/km^2) and 1,107 sea otters (SE = 541.38) in the low density stratum (0.30/km^2, Tables 3a and 3b). We estimated there were 7,513 sea otters (SE = 1,743.67) in the non-replicated survey area and 7,067 sea otters (SE = 716.25) in the replicated survey area.

Table 1. Summary of Intensive Survey Unit (ISU) results from sea otter surveys, Kodiak Archipelago, 2014.

Replicate	ISUs (n)	Strip count total	Circle count total	Correction factor	SE
Non-replicated	27	36	107	2.97	0.94
Replicate 1	34	103	197	1.91	0.13
Replicate 2	31	214	324	1.51	0.11

Sea otter abundances and group sizes varied across the study area (Figure 2). Group sizes ranged from one to 159 sea otters, but the distribution of group sizes was heavily left skewed (median group size = 1). We observed the highest densities and the largest groups of sea otter adjacent to northern and western Kodiak Island (e.g., Chiniak Bay, Viekoda Bay, Uganik Bay, Spiridon Bay, and Uyak Bay); and south of Raspberry and Afognak Islands in Afognak Bay, Raspberry Straight, and Kupreanof Straight). We observed few (<10 total) sea otters adjacent to eastern Kodiak Island (e.g., Kalsin Bay to Alitak Bay). We observed 14 small groups, each comprising less than 7 individuals in the southwest tip of Kodiak Island (Alitak Bay to Karluk River outlet) that had not been previously surveyed. Our results indicate that sea otter abundance at Kodiak have increased significantly from 5,894 (SE = 1,342) in 2001 to 13,274 (SE = 1,885) in 2014 (Figure 33). However, abundances in 2014 are comparable to abundances in 1989 when sea otters numbered 13,526 (SE = 1,119).

Table 2. Sea otter population estimates, Kodiak Archipelago, 2014.

Survey area	Stratum	Area (km2)	Pop. est.
Non-replicated	H - small groups	3,815.22	4,785
Non-replicated	L- small groups	3,697.58	742
Non-replicated	H - large groups	3,815.22	316.03
Non-replicated	L- large groups	3,697.58	365
Non-replicated total		7,512.80	6,207
Replicate 1	H - small groups	971.30	4,898
Replicate 1	H - large groups	971.30	921
Replicate 1 total		971.30	5,819
Replicate 2	H - small groups	971.30	6,502
Replicate 2	H - large groups	971.30	1,812
Replicate 2 total		971.30	8,314
Mean of replicates		971.30	7,067
Total population estimate		8,484.10	13,274

Table 3a. Sea otter survey results by survey strata, Kodiak Archipelago, 2014.

Stratum	# otters counted	Raw pop. est.[1]	SE	Correction factor[2]	Adjusted pop. est.[3]	SE
High	1,022	5,038	505.76	2.08	10,485	1,843.41
Low	13	250	117.34	2.97	742	405.85
Total	1,731	5,244	519.19	2.16	11,226	1,887.56

[1] Number of otters counted *(transect area/survey stratum area)
[2] Based on comparison of strip counts to ISU counts
[3] Raw population estimate * correction factor

Table 3b. Sea otter survey results by survey strata (continued), Kodiak Archipelago, 2014

Stratum	Complete counts[1]	Complete counts, population est.[2]	SE	Final pop. est.[3]	SE
High	342	1,683	612.50	12,168	1,942.50
Low	19	365	358.30	1,107	541.38
Total	365	2,048	709.85	13,274	2,016.54

[1] Counts of otter groups that were photographed or ISU counts
[2] Complete counts * (transect area/survey area)
[3] Adjusted population estimate + complete count population estimate

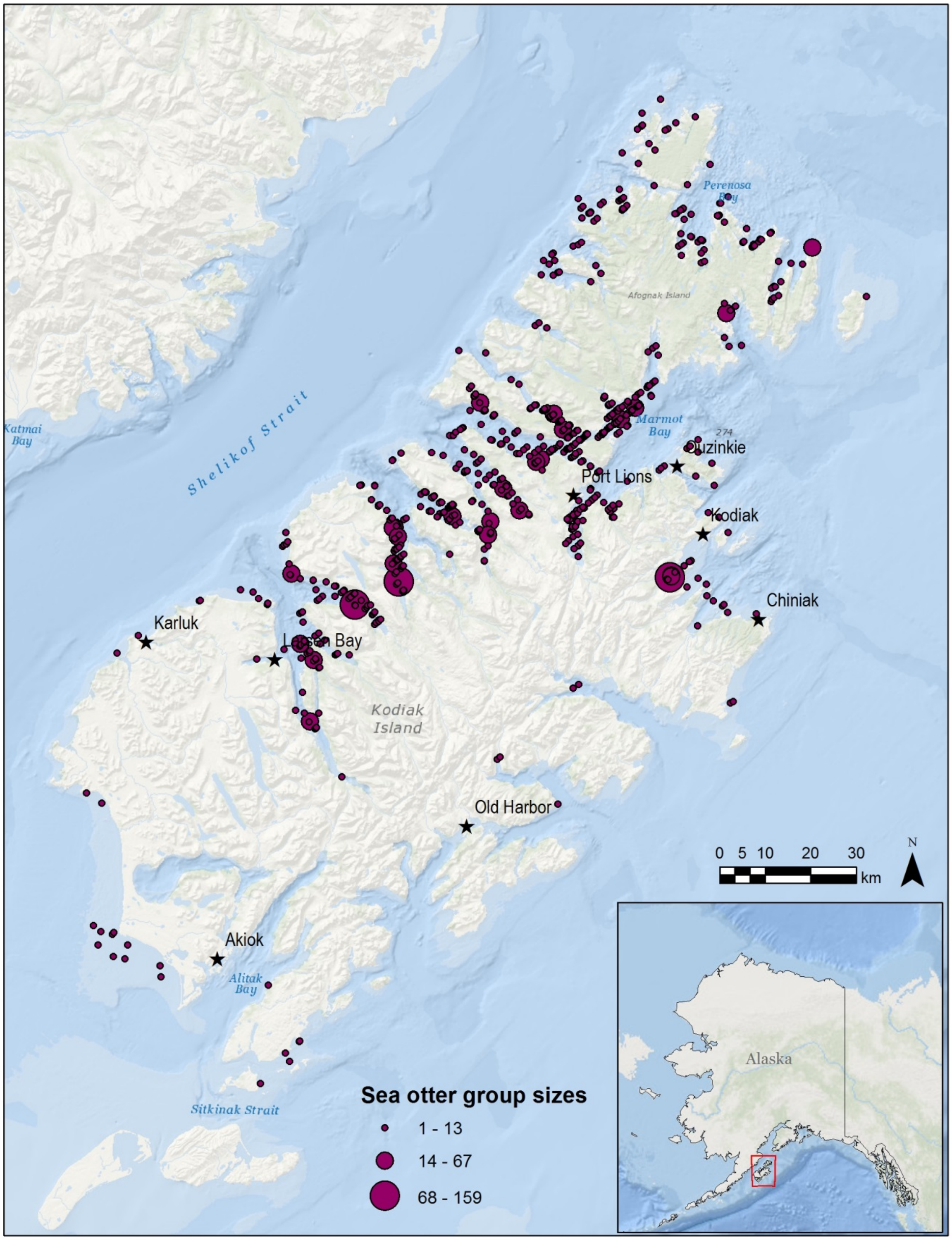

Figure 2. Sea otter group sizes observed during aerial surveys, Kodiak Archipelago, Alaska, 2014. Group sizes ranged from one to 159 sea otters.

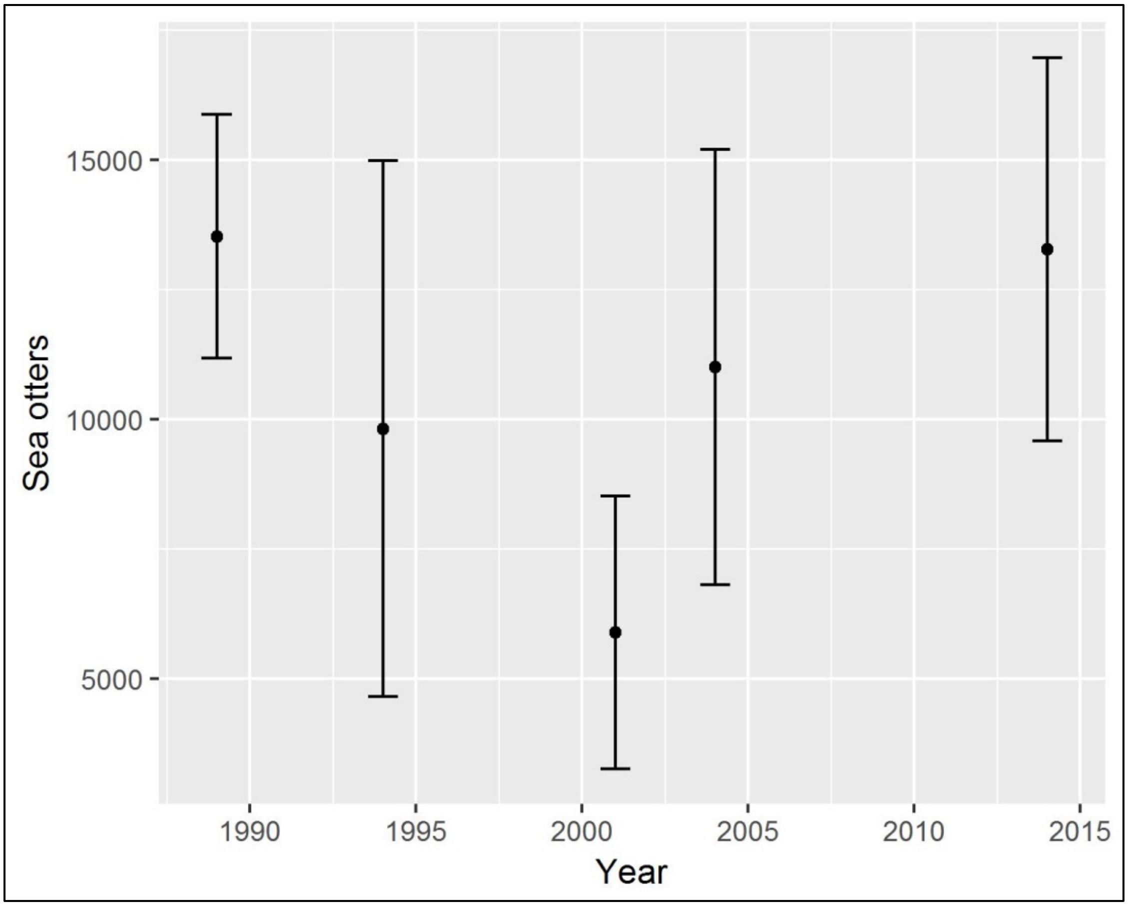

Figure 3. Estimated sea otter abundances, Kodiak Archipelago, Alaska. Previous surveys occurred in 1989 (Degange et al. 1995), 1994 (unpublished data), 2001 (unpublished data), and 2004 (unpublished data). All surveys but 1989 followed the same protocol (Bodkin and Udevitz 1999) and surveyed a comparable study area. Error bars show 95% confidence intervals.

Discussion

Our estimate of 13,274 sea otters (SE = 1,885.04) for the Kodiak Archipelago is the highest estimate for the region since 1989, when abundances were estimated at 13,536 sea otters (SE = 1,199). After 1989, sea otter abundances steadily declined to a low of 5,894 (SE = 1,342) in 2001 before rebounding to 11,005 sea otters (SE = 2,138) in 2004.

We found the highest densities of sea otters in the straights between Kodiak, Raspberry and Shuyak Islands. Alternatively, we observed very few sea otters on the east side of Kodiak Island, despite what appeared to be suitable habitat (protected bays, shallow water, and evidence of a thriving crab fishery). Without empirical data on habitat quality within this region, we can only speculate that sea otters have not fully expanded to all available habitats around Kodiak. There are a number of possible causes for the apparent lack of sea otters in this region. A geographic bottleneck could be inhibiting population expansion to the east side of Kodiak Island. Alternatively, other limiting factor, such as human harvest, could be contributing to the lack of sea otters in that area. Notably, while surveying the east side of Kodiak, we observed amble evidence of crab fishing activity (string of markers) along the east side of Kodiak. Sea otters are commonly viewed as a nuisance competitor by crab fisherman. Residents of the village of Old Harbor, along the east side of Kodiak Island, have indicated that they readily harvest sea otters when given an opportunity (Cobb personal communication).

Although quantifying spatial changes in abundance across Kodiak Archipelago was not an objective of this survey, our counts suggest substantial changes have occurred in the relative distributions of sea otters. Most notably, we counted more sea otters in the northern bays of Kodiak Island, including Womens Bay, than previous surveys. Our observation of increased sea otter numbers in Womens Bay is corroborated by public comments regarding a perceived increase in sea otters and an associated decline in Dungeness crab (*Metacarcinus magister*) abundances. High abundances of sea otters in this region have been perceived as a cause for crab declines, although empirical evidence for this is absent.

Tides appeared to effect the distribution and grouping behavior of sea otters during our survey effort. Sea levels at Kodiak can vary up to 4 m depending on the tide stage. In the nearshore areas occupied by sea otters, this difference likely influences sea otter distributions by altering forage accessibility, which then impact whether sea otters are likely to be repeatedly counted on the same transect. To address this source of variation, future efforts should consider tide stage when scheduling replicate surveys and made attempts to schedule replicate surveys at a similar tide stage. Alternatively, tide stage could potentially be included as a covariate in models of abundance.

An observer's ability to detect sea otters during aerial surveys can vary with sea surface conditions. During this survey, sea stage (chop) may have had a substantial impact on our ability to see sea otters. When seas were calm and mirror-like (Beaufort scale of 1 to 2) , we were able to see ripples from sea otters eating at the surface and wake extending from moving sea otters at great distances (>1 km). When winds increased, even small wavelet obscured signs of sea otters and greatly reduced detection distance. In addition to shop, glare off the water during cloudless days reduced our perceived ability to detect sea otters. The impacts from glare varied depending on the angle of the sun and aircraft flight path. We collected transect-level data on sky condition and sea state during this survey but these covariates where not used to model detection rates. Based on these observations, we recommend that future abundance estimates could be more precise by including transect-level survey condition covariates affecting detection rates.

A number of factors affected the overall precision of our estimates. We believe that the relative locations and movement patterns of large sea otter groups (rafts) impacted variances in our abundance estimates. On occasions, we observed large (>50) groups of sea otters that were just beyond the strip transect boundary, and therefore we did not include them in our count, per protocol. In areas where we conducted a replicate survey in the same area, we occasionally would observed large sea otter groups within the transect boundary. A similar survey at Kachemak Bay found considerable variation in abundance estimates among five replicates (Gill et al. 2009). The authors attributed the variation among replicates to the highly mobile nature of sea otters and large group sizes, particularly in low density strata, and indicated that a single replicate was unsuitable for that region. To account for this source of variation, we recommend at least two replicate surveys and more if possible.

Regularly assessing the population status of Kodiak sea otters is a high priority for the FWS. Although the local sea otter population at Kodiak appears to be stable to increasing in size, this population is within the southwestern Alaska distinct population segment and therefore listed as threatened under the Endangered Species Act. Causes for the declines in other areas in the threatened population segment are unknown. By comparing population trends and their limiting factors at Kodiak to nearby populations that are declining, researchers might be able to quantify what conditions at Kodiak have allowed for population stability and strive for these conditions at struggling populations.

Understanding trends in abundance of sea otters can be important even for stable to increasing populations. High density and expanding populations of sea otters can be viewed as a nuisance to human because of perceived competition with subsistence and commercial shellfish harvest. Sea otters in southeastern Alaska have increased dramatically recently, which has led to calls for increased harvest in that region. Residents of the town of Kodiak have expressed concern over increases in sea otters in Womens Bay and its potential impact on the Dungeness crab fishery. The goal of this study was to produce an estimate of abundance for a large region (Kodiak Archipelago) and therefore we caution against using these data to make conclusions about changes to localized areas within the study area. That said, completing a focused survey in a smaller region is technically feasible with additional replicates of the Bodkin-Udevitz protocol, and this could produce a more precise estimate of abundance for a localized area, such as Womens Bay.

Acknowledgements

Taj Shoemaker safely and effectively piloted the surveys. USGS Alaska Science Center (Dan Monson and George Eslinger) trained the observer in the survey protocol. George Eslinger provided assistance with data analysis. Funding for the survey came from the FWS Inventory and Monitoring Program and the FWS Marine Mammals Management office.

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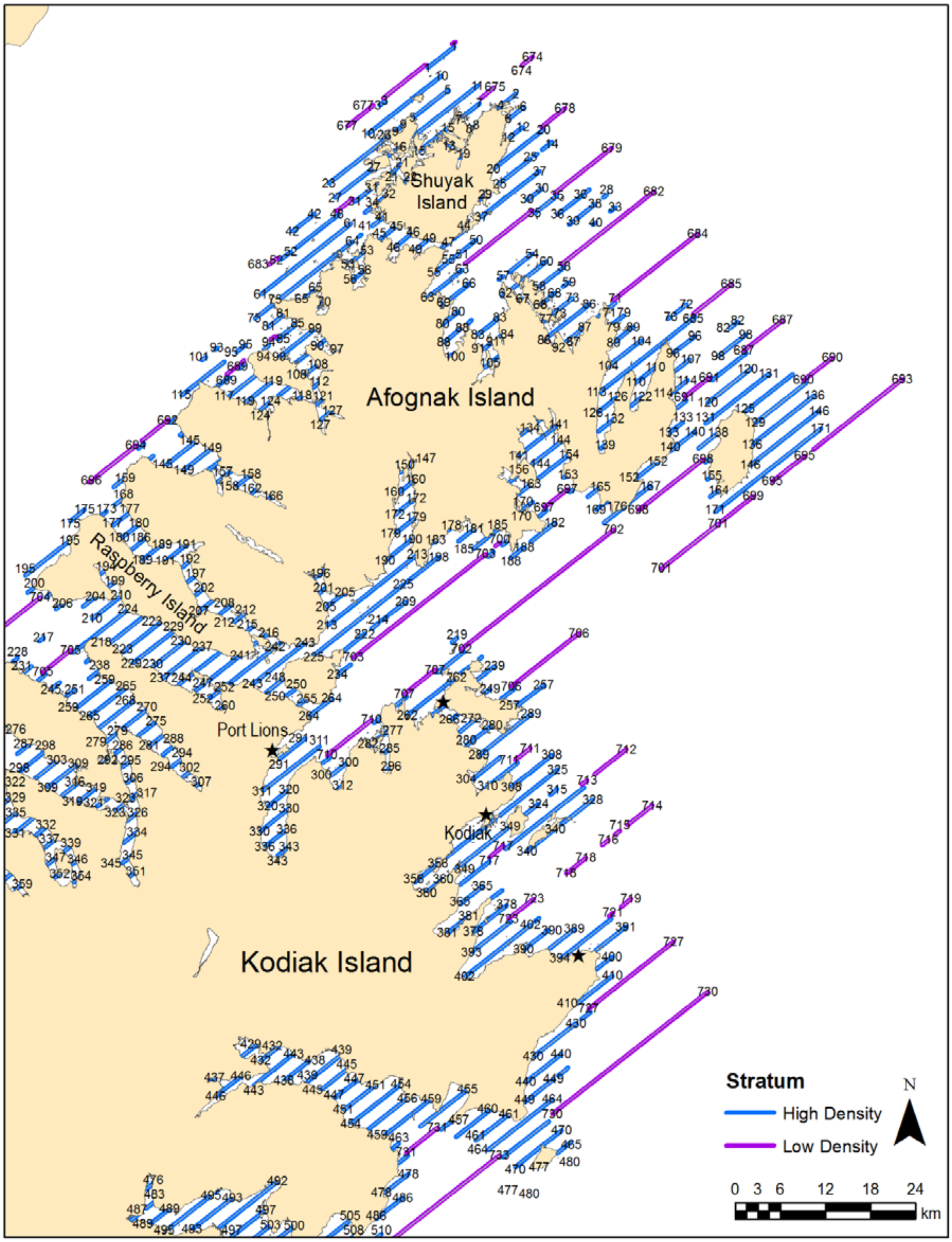
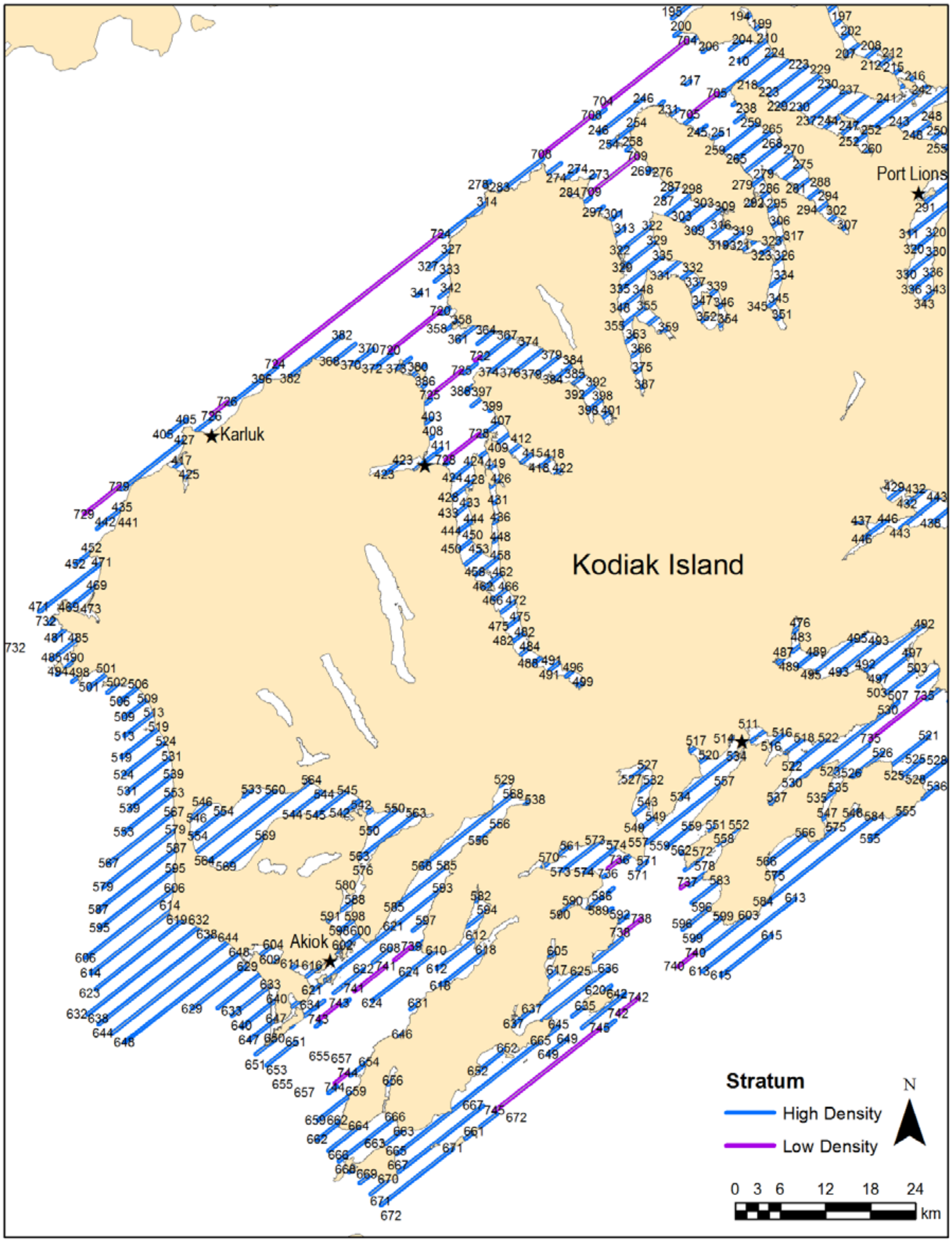
Appendix A. Summary of flight times and dates required to complete sea otter survey, Kodiak Archipelago, 2014.

Date		Flight hours
7/2/2014		6.42
7/3/2014		2.00
7/5/2014		6.00
7/7/2014		7.67
7/8/2014		3.17
7/9/2014		7.17
7/11/2014		6.08
7/13/2014		3.92
7/14/2014		5.50
7/15/2014		5.92
7/16/2014		1.00
7/17/2014		7.33
7/18/2014		6.17
7/23/2014		1.08
7/24/2014		6.42
7/25/2014		3.42
7/27/2014		7.33
7/30/2014		7.75
7/31/2014		0.75
8/1/2014		4.67
	Total hrs	99.75

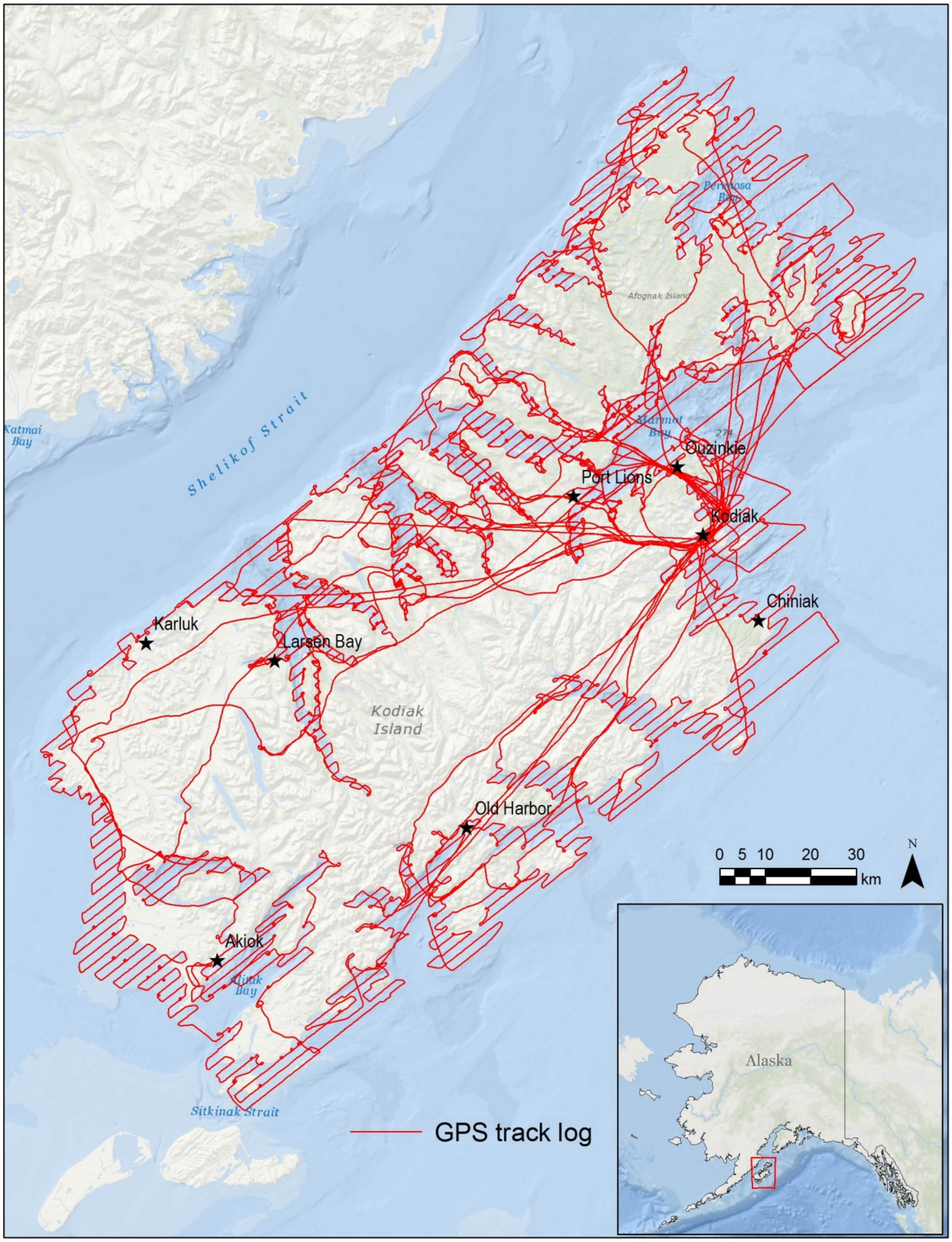
Appendix B. Sea otter survey transect numbers, northern region, including Shuyak, Afognak, Raspberry, and Kodiak Islands.



Appendix C. Sea otter survey transect numbers, southern region, including Shuyak, Afognak, Raspberry, and Kodiak Islands.



Appendix D. GPS track log showing the flight path of the survey aircraft, Kodiak Archipelago, Alaska, 2014.



Appendix E. Distribution of transects surveyed once (one replicate) and twice (two replicates), Kodiak Archipelago, Alaska, 2014.