ASSESSMENT OF THE RIVER OTTER POPULATION IN PRINCE WILLIAM SOUND

Alaska Department of Fish and Game and Chugach National Forest
Interagency Collaborative Project Final Report
Project AG-0120-P-09-0083

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SUMMARY

We present the results of river otter (*Lontra canadensis*) latrine site surveys and population density estimates conducted in western Prince William Sound during 2009–2011. We discuss the results of the field survey conducted in 2009 and the DNA analysis and mark-recapture estimations conducted in 2010. We also present results of the recently completed field survey conducted in June 2011, which expanded the investigation to include harvested portions of western PWS. The 2011 work is essential to the testing and development of the mark-recapture methods as well as to providing a better understanding of the potential effects of harvest and refugia on the sustainable yield of river otter populations.

During June 2009, we conducted a density estimate using mark-recapture of fecal DNA collected during repetitive samples of scats <24 hours old among 60 active latrine sites along 110 km of the northern Knight Island Archipelago. Among the 60 sites sampled, we counted nearly 2000 fresh scats during the 10-day sampling period. Of those scats, we collected 787 of the freshest for DNA analysis. The mean number of all fresh scats/site/day counted was 2.9 and collected was 1.2. Of the 787 samples collected, 129 (or 16.4%) were successfully genotyped with at least 7 of the 8 primers (Lut701, Lut733, Lut801, Lut829, Rio-01, Rio-05, Rio-17, and Rio-19), representing 78 unique individuals. Of these, 56 animals were observed only once and 22 were identified between 2 and 5 times.

To estimate capture and recapture probabilities, and population size, we used closed population models. We compared the fit of models including individual heterogeneity with those that did not account for heterogeneity using AICc. Because in all cases, models with no heterogeneity had lower AICc and higher weight, we conducted the subsequent analyses using simple closed capture models. In these analyses, we incrementally reduced the number of occasions from 11 to 6 and estimated population size with several competing

models. The average abundance estimate from the different models was 145 otters (range 131–166). The 95% confidence intervals ranged from 88 – 265 using the data for 6 occasions to 108 – 173 using all 11 occasions, suggesting that when capture and recapture probabilities are low a higher number of occasions will be needed to accurately estimate population size of river otters in this system.

During 21–30 June 2010, we conducted surveys to identify active latrine sites along 340 km of western Prince William Sound coastline, focusing on Cochrane Bay, Eaglek Bay, and Port Wells. We located 231 active latrine sites, resulting in an average density of 68 sites per 100 km. We counted 64 latrine sites in Cochrane Bay, 72 in Eaglek Bay, and 95 in Port Wells. At each new site in each area, we evaluated and recorded habitat features within a 10-m radius of the main entrance from the water. These features included aspect; exposure to wave action; slope of the vegetated and tidal areas (in degrees); composition of intertidal substrate ranked according to percent cover of sand, gravel, small and large rock and bedrock; composition of vegetation cover based on percent overstory and understory vegetation and old growth trees; and potential burrow sites.

During 20 June–3 July 2011, we conducted a density-estimation survey along 281 km of coastline in eastern Esther Passage, Eaglek Bay, and western Unakwik Inlet in western Prince William Sound. Of the 106 known and new latrine sites we examined, 79 sites contained a sufficient number of old and new scats to be surveyed, were well distributed along the coastline, and were located in places that were accessible at all tide levels. Of those 79 latrine sites, we sampled 22 in Esther Passage, 39 in Eaglek Bay, and 18 in Unakwik Inlet. Our sampling intensity for the 79 latrine sites along 281 km of coastline was 28 sites per 100 km compared with 38 sites per 100 km for the original 106 latrine sites. Among the 3 bays surveyed, we collected 438 scat samples (daily mean = 54) and 85 hair samples (daily mean = 12). Scat collections per site were higher in total, and on average, for Eaglek Bay versus Esther Passage and Unakwik Inlet, although average hair collection per site was higher in Unakwik Inlet. Daily scat collections for the overall area ranged between 31 scats on 30 June and 71 scats on 26 June, while hair collections ranged between 10 samples on 27 and 30 June and 18 samples on 29 June. We anticipate results from the DNA analysis by June 2012.

Analysis of habitat availability and selection by river otters for latrine sites as well as harvest densities and patterns for the above survey areas are underway and will be presented in a later report.

BACKGROUND

The Alaska Department of Fish and Game (ADF&G), the University of Wyoming (U of W), and the U.S. Forest Service – Chugach National Forest (USFS–CNF) initiated this collaborative project in 2009. This project, conducted through Sikes Act authority, is part of a larger, continuing investigation of river otters (*Lontra canadensis*) in south-central Alaska by ADF&G (Bray and Golden 2009, Golden 2009). The goals of this investigation are: (1) to obtain population estimates for river otters in the Prince William Sound; and (2) to analyze river otter abundance relative to human activities (e.g., trapping). This information should provide CNF with a better understanding of the influence of human activities on river otter populations and availability of their habitat. Overall, the collaborative work between USFS and ADF&G should improve our capacity to manage and monitor the viability of river otters in the region.

The information gathered here will provide a better understanding of river otter populations and their ecology in the Prince William Sound. This information is important, because it enables managers of the Chugach National Forest to continue offering premier recreational opportunities while concurrently providing for viable river otter populations. There are three objectives for our collaborative research: (1) to measure relative and actual abundance of river otters through latrine site sampling of scats and activity levels; (2) to examine river otter harvest levels and extent of refugia; and (3) to develop a model to estimate potential sustainable yield for river otter populations.

The first phase of this investigation was to conduct an intensive test of the mark-recapture technique for estimating river otter density based on DNA extracted from their feces. Estimates derived from previous river otter scat sampling indicated poor recapture rates, which likely would result in unreliable estimates. Our objective in June 2009 was to conduct a rigorous test of the mark-recapture methodology to determine whether the low recapture rates could be due to sampling protocol or to the DNA extraction and identification process. Our objective during FY2010 (1 July 2009–30 June 2010) was to process all scats collected in 2009, conduct DNA analyses, and perform mark-recapture testing and evaluation. The latter objective is the portion of this investigation that was funded in part by USFS–CNF for Project AG-0120-P-09-0083 during the performance period of 10 July 2009–1 December 2010.

In this final report, we present the results of the field survey conducted in 2009 and the DNA analysis and mark-recapture estimations conducted in 2010. We also present results of the recently completed field survey conducted in June 2011, which expanded the investigation to include harvested portions of western PWS. The 2011 work is essential to the testing and development of the mark-recapture methods as well as to providing a

better understanding of the potential effects of harvest and refugia on the sustainable yield of river otter populations.

Because of the scope of this project, our analysis will continue for at least another year on the following aspects: (1) processing fecal DNA and the identification of individual otters, (2) analysis of the most appropriate mark-recapture technique to use in estimating river otter density, (3) assessment of habitat use and availability related to latrine sites, and (4) analysis of harvest patterns and density. We present this work as a reflection of the long-term collaboration among ADF&G, U of W, and USFS–CNF to achieve our mutual goals, and as the project deliverable for USFS-CNF funding for the 2009–2010 DNA analysis. The 2011 field surveys were funded by ADF&G and a grant from the National Fish and Wildlife Foundation (NFWF).

METHODS

Shoreline lengths discussed in this report were calculated using ArcMap 10 (ESRI, Redlands, CA) from a National Oceanic and Atmospheric Administration (NOAA) base layer at the 1:63,360 scale. We will conduct future analyses using a higher-resolution layer to enhance our understanding of habitat availability and use by river otters among several study areas.

2009 Density Estimation

Field Survey

We conducted a density-estimation survey along 110 km of coastline in the northern portion of Knight Island Archipelago in western Prince William Sound during 1–14 June 2009 (Figure 1). We selected that coastline because of the long history of river otter research in the area since the *Exxon Valdez* oil spill (EVOS). It was also selected because there has been little or no harvest of river otters in the archipelago.

Based on previous studies, e.g., Testa et al. (1994) and Bowyer et al. (2003), we estimated that the area supported at least 50 river otters, which represented the minimum number of animals sufficient for testing the mark-recapture technique (E. Becker: ADF&G Biometrician; pers. commun.). Since EVOS in 1989, researchers have found and sampled over 300 latrine sites in the Knight Island Archipelago, which includes northern Knight Island, Lower Passage, Ingot Island, and Eleanor Island. Because many of those 300+ sites have not remained active over the years, we began our site selection for this test using 100 active sites recently sampled by Roe et al. (2010) during their research of river otters in the same area during 2006–2008 (Figure 2).

From that *a priori* selection of 100 latrine sites, we randomly selected 70 for pre-marking. The purposes of pre-marking were (1) to identify those sites with the most recent activity (based on the number of fresh scats) that would adequately represent the area, (2) to limit the number of sites for sampling to 60, which was the number we believed would be manageable for 2 crews to survey daily, and (3) to ensure that only fresh scats (i.e., < 24 hrs old) would be included in the mark samples. Our sampling intensity for the 60 latrine sites along the 110 km of coastline was 54 sites per 100 km compared with 91 sites per 100 km for the original density of 100 latrine sites (Figure 2).

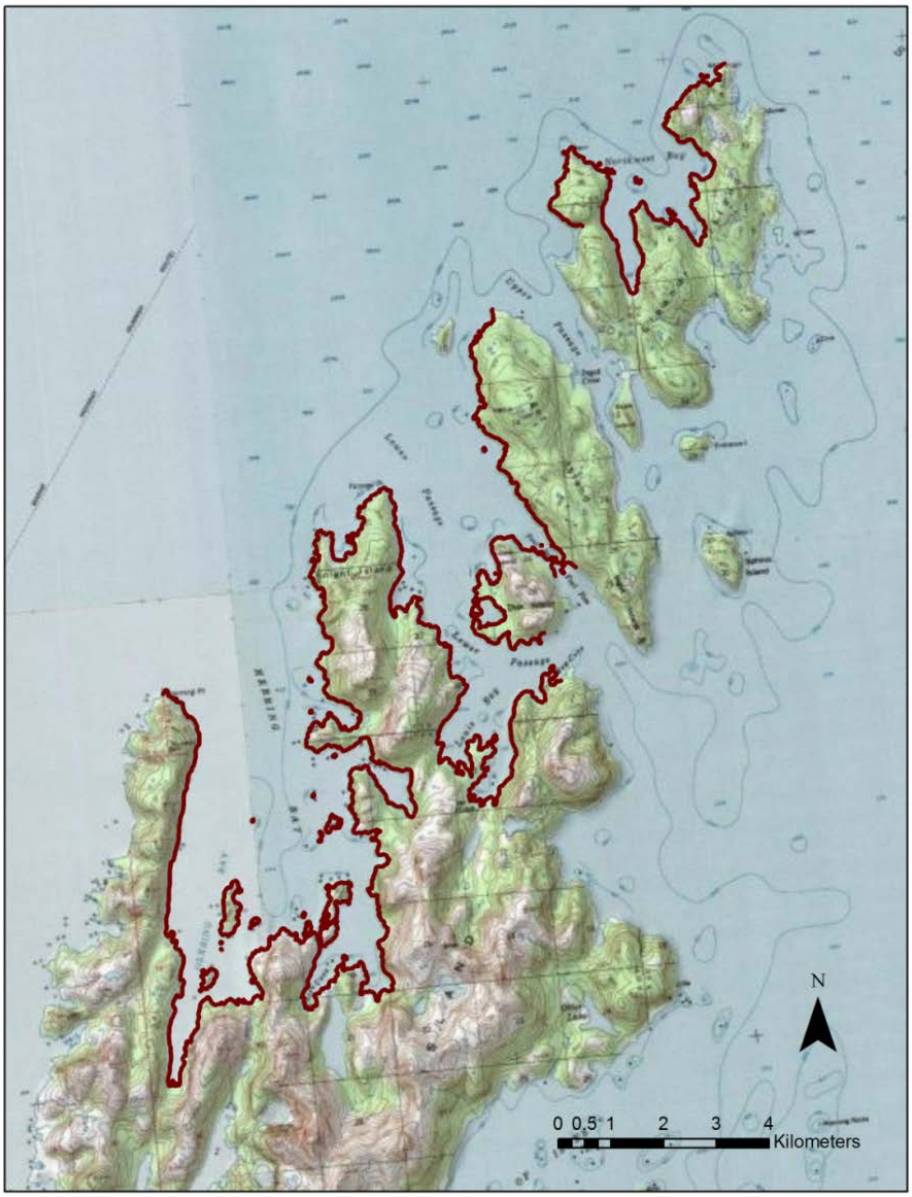

Figure 1. Coastline surveyed (red line = 110 km) for the mark-recapture test in the Knight Island Archipelago, Prince William Sound, 2–13 June 2009.

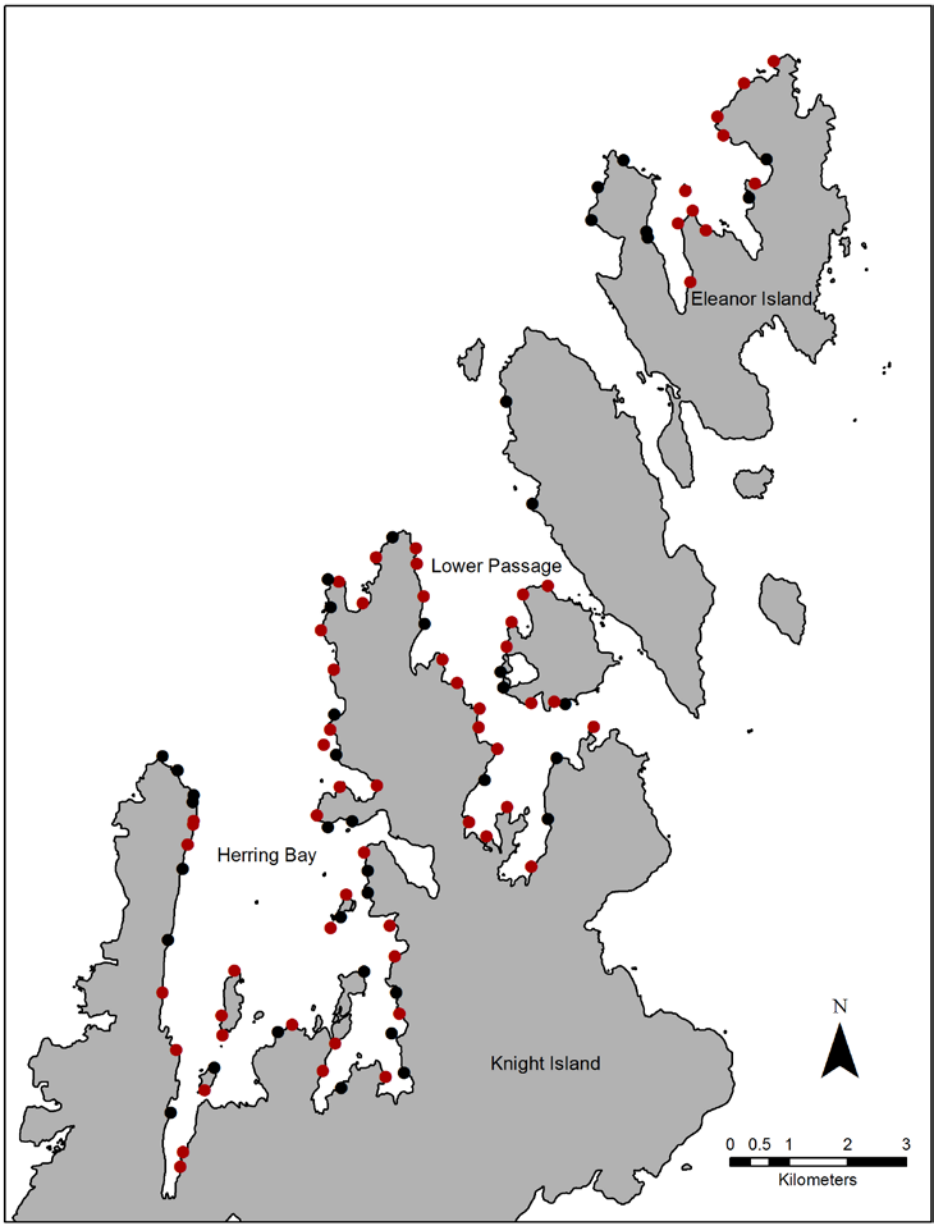

Figure 2. River otter latrine sites (60) selected (red dots) from original 100 sites (all dots) for the mark-recapture test in the Knight Island Archipelago, Prince William Sound, 2–13 June 2009.

We conducted this survey with 2 crews of 3 people each using 2 Boston Whaler skiffs (17-foot and 18-foot) working from the live-aboard vessel M/V Babkin. We also occasionally supplemented with a crew of 2 sampling from a 12-foot Zodiac. We used 1 and 14 June as travel days between Whittier and the survey area. On 2 June, we pre-marked 70 sites by counting all old and fresh scats and by marking them with colored glitter, which effectively excluded them from further sampling. That evening we reviewed the scat counts from the sites we surveyed and chose the final 60 sites that would be part of the mark-recapture sampling process. We conducted the mark-recapture survey on those 60 latrine sites

during 3–13 June (Figure 2). We began the initial sample (or first mark) on 3 June by searching for and counting all fresh scats (i.e., scats that had been deposited during the previous 24 hours). Of those fresh scats, we collected the freshest (i.e., with the highest moisture content, strongest smell, or obvious mucus) for DNA analysis to identify individual river otters. Collected scats were preserved as described below.

We repeated the process of counting, collecting, and preserving fresh scats at all 60 sites daily for the next 10 days. The length of the sampling period was designed to ensure that the number of sampling occasions exceeded 9 consecutive days. Previous work in Prince William Sound suggested that estimates of otter abundance can be biased with shorter sampling efforts (Ben-David and Golden 2009). By sampling for 10 days and later subsampling from this dataset, we intend to determine the optimal sampling intervals (i.e., when the population estimate reaches an asymptote) for future work. Each day, we continued to glitter any uncollected fresh scats, remnants of collected scats left on sites, and any old scats missed during pre-marking. Weather conditions remained favorable during the entire survey period, with only scattered showers; however, ambient temperatures occasionally exceeded 12°C (54°F), which could reduce the quality of the DNA in the feces (Ben-David and Golden 2009).

We collected and preserved fresh river otter scat samples found at latrine sites in labeled plastic vials filled with 100% ethanol in preparation for laboratory processing. All samples were kept cold but not frozen (in coolers with ice) to preserve the samples in the field until they could be shipped to the laboratory at the University of Wyoming.

DNA and Mark-Recapture Analysis

During July 2009–May 2011, we analyzed river otter DNA from the scat collections and used those results to perform mark-recapture tests and to estimate otter density along the coastline surveyed during June 2009.

In the laboratory, DNA is extracted from intestinal cells shed within otter feces. By amplifying this nuclear DNA, genetic fingerprints of microsatellite loci specific to individual animals are generated. Microsatellites are hypervariable, noncoding regions of short repeats within the genome that vary in size among individuals. They can serve as genetic markers because the regions may be amplified and their sizes compared among individuals with the aid of appropriate markers through polymerase chain reaction (PCR) products and specific microsatellite primers. This allows the identification of individuals from DNA microsatellites to conduct a mark-recapture analysis of population density.

We first cleaned all samples by sieving, but large quantities of crab carapace slowed the cleaning process. We then extracted all samples with QIAGEN QIAamp® DNA stool MiniKit (QIAGEN Inc, Valencia, CA). All samples were amplified up to 5 times with 8 hypervariable microsatellite primers developed for Eurasian otters (*Lutra lutra*; Lut-701, Lut-733, Lut-801, Lut-829) and river otters (Rio-01, Rio-05, Rio-17, Rio-19) (Dallas and Piertney 1998, Beheler et al. 2004, Beheler et al. 2005). Amplifications of microsatellite loci were performed in a PTC200 Peltier thermal-cycler (MJ Research Inc, Waltham, MA). PCR products were resolved on an Applied Biosystems 3730 capillary sequencer (Applied Biosystems Foster City, CA).

We used the program MARK to estimate population size and evaluated the emergence of an asymptote in relation to the number of sampling occasions. In these analyses, we considered the potential effects of covariates such as ambient temperature and genotyping success.

2010 Latrine Site Survey

We conducted surveys for active latrine sites along 340 km of western Prince William Sound coastline during 21–30 June 2010 (Figure 3). The coastlines selected had not been surveyed previously but were chosen because they receive relatively moderate to high recreational or trapping activity. The areas surveyed were Cochrane Bay, Eaglek Bay, and Port Wells. All three areas are within easy reach of Whittier, Alaska, which is the western gateway to PWS.

We used the Esther Fish Hatchery as our base of support. We conducted the surveys with 2 crews of 3 people each using 2 Boston Whaler skiffs (17-foot and 18-foot). The surveys consisted of slowly searching the coastlines for latrine sites, which were identified based on signs of activity such as trails from shore into the forest, algae on rocks just below the vegetated edge, and old growth above bedrock or large rock substrate.

The location of each positive site (i.e., one containing new scats or at least 10 total scats) was recorded with a GPS unit. At each new site in each area, we evaluated and recorded habitat features within a 10-m radius of the main entrance from the water (Bowyer et al. 1995, Bowyer et al. 2003). These features included aspect; exposure to wave action; slope of the vegetated and tidal areas (in degrees); composition of intertidal substrate ranked according to percent cover of sand, gravel, small and large rock and bedrock; composition of vegetation cover based on percent overstory and understory vegetation and old growth trees; and potential burrow sites. At each site, we counted the number of old and relatively fresh scats.

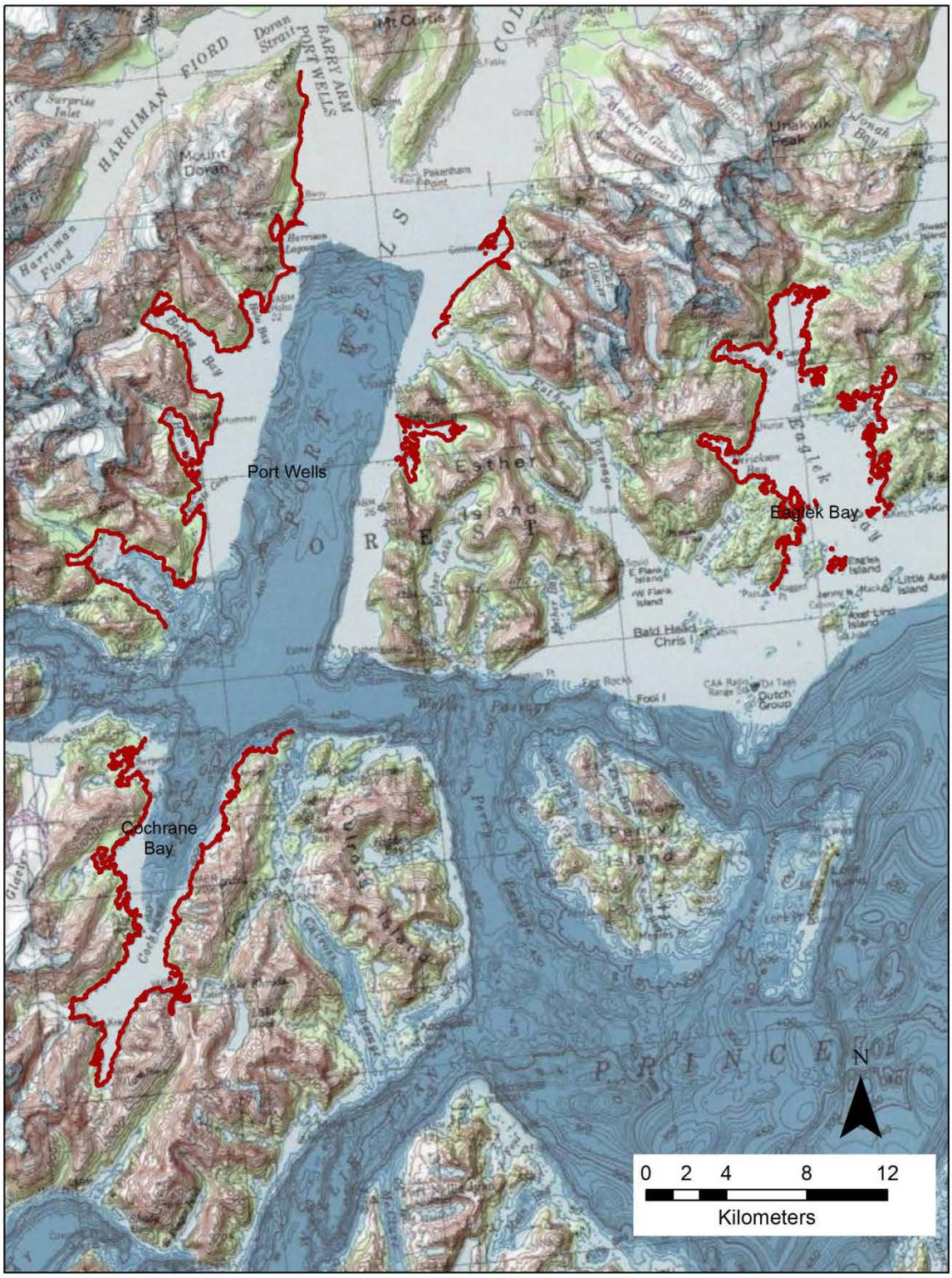

Figure 3. Coastline surveyed (340 km) to identify latrine sites in western Prince William Sound during 21–30 June 2010.

2011 DENSITY ESTIMATION

Field Survey

We conducted a density-estimation survey of along 281 km of coastline in eastern Esther Passage, Eaglek Bay, and western Unakwik Inlet in western Prince William Sound during 20 June–3 July 2011 (Figure 4). We traveled from Whittier, Alaska to the survey area on 20 June. For the next 3 days (21–23 June), we conducted a pre-survey of the entire coastline in the area to examine previously identified latrine sites and to find new latrine sites in preparation for scat and hair sampling. Many of the latrine sites in Eaglek Bay were first identified during the June 2010 survey (Figure 5).

For the pre-survey, we examined the level of activity on each site by counting old and fresh scats deposited by otters. Sites with at least 10 old scats and 2–3 fresh scats were considered active and suitable for potential survey. Out of the 106 known and new latrine sites we examined, 79 sites contained a sufficient number of old and new scats to be surveyed, were well distributed along the coastline, and were located in places that were accessible at all tide levels (Figure 5). Of those 79 latrine sites, we sampled 22 in Esther Passage, 39 in Eaglek Bay, and 18 in Unakwik Inlet (Figure 5). Our sampling intensity for the 79 latrine sites along the 281 km of coastline was 28 sites per 100 km compared with 38 sites per 100 km for the original 106 latrine sites.

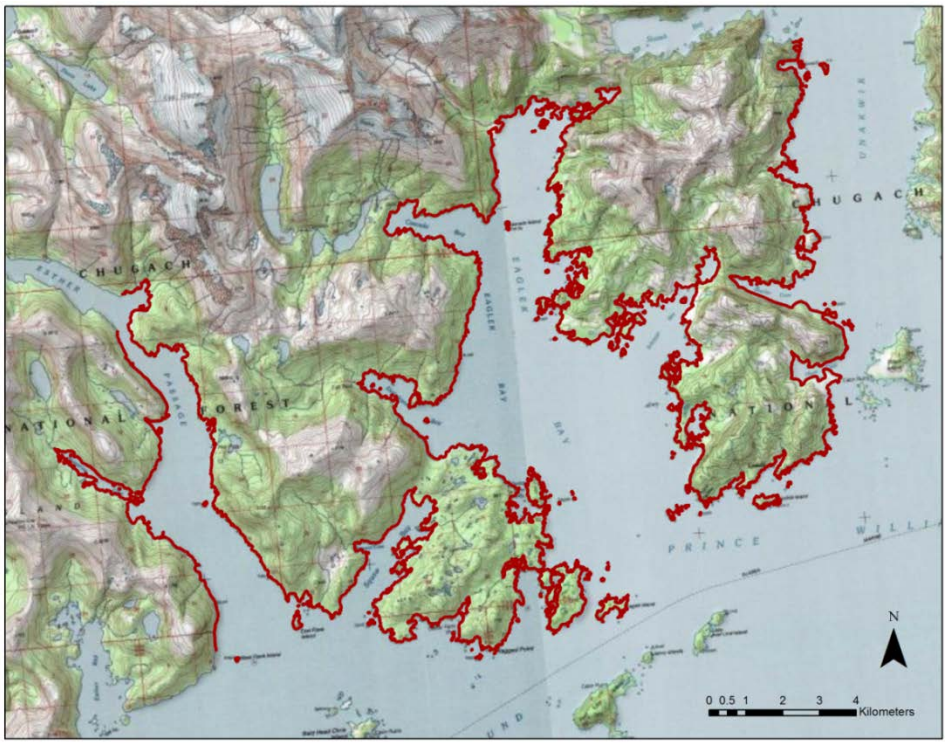

Figure 4. Coastline surveyed (281 km) for the mark-recapture test in northwestern Prince William Sound during 20 June – 3 July 2011.

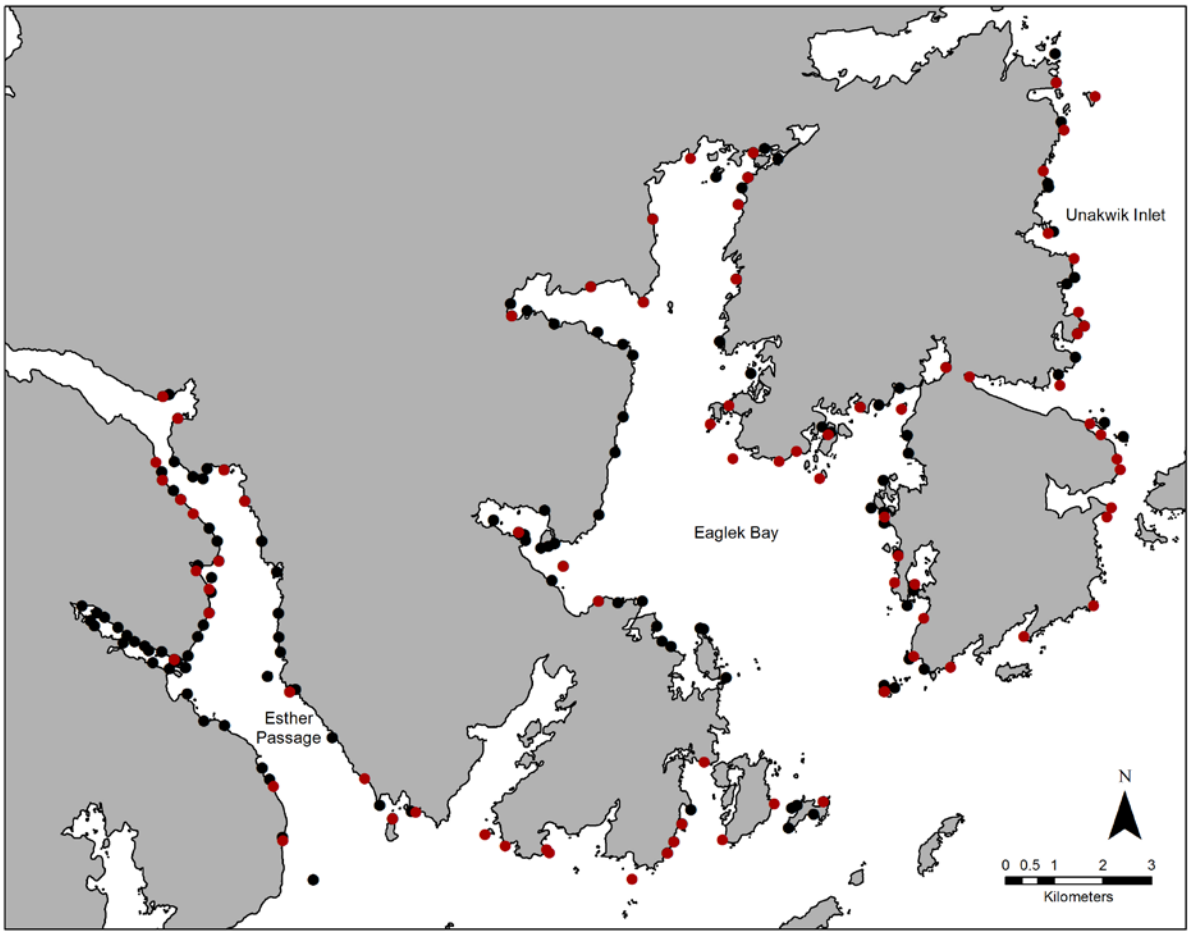

Figure 5. River otter latrine sites (79) selected (red dots) from original 106 sites (all dots) for the mark-recapture test in northwestern Prince William Sound during 20 June – 3 July 2011.

In final preparation for scat and hair sampling, we visited 79 selected sites on 24 June and marked all scats with colored glitter to eliminate the chance of sampling any scats > 24 hours old. We also set hair snares on most of the sites during 24–25 June to supplement the collection of DNA from individual otters. We began sampling scats on 25 June and hair on 26 June. Each subsequent day through 2 July, we collected scats and hair from all sites using crews of 2–3 people each among 4 skiffs. This resulted in consecutive collections of scat over 8 days and hair over 7 days.

To help ensure scat samples with relatively high concentrations of DNA, we focused on collecting only scats that contained visible and collectible amounts of intestinal mucous or anal jelly (which seems, in part, to be a protective substance secreted to reduce injury from fish bones). We preserved all scat samples in sealed plastic vials with 100% ethanol and stored them in coolers with ice. If sufficient fecal material was available, we also preserved

a portion of each scat in a buffer solution, with the intent of comparing its efficacy to ethanol as a preservative.

We used commercially made snares to collect hair. We modified the snares by clipping strands of the twisted wire so that they would snag hair but not injure the otters (DePue and Ben-David 2007). We also replaced the snare lock with a small paper clip that would open as the snare tightened down. This allowed the snare to fall to the ground so that only hair from one otter would be caught, helping prevent cross-contamination and thereby reducing genotyping error (DePue and Ben-David 2007). Hairs collected from each snare were stored in small plastic vials with desiccant. We then used lighters to burn off any organic material remaining on the snares before resetting them. We picked up all snares from sites on 2 July.

DNA and Mark-Recapture Analyses

Since July 2011, we have been processing scat samples and conducting DNA analyses as described above for the 2009 survey at the University of Wyoming lab. We will use the results from those analyses to perform mark-recapture tests and to estimate otter density along the coastline surveyed during June–July 2011.

HABITAT AND HARVEST ANALYSIS

Analysis of habitat availability and selection by river otters for latrine sites as well as harvest densities and patterns for the above survey areas are underway and will be presented in a later report. These analyses include spatial and temporal variation in habitat selection patterns based on field measurements described above (Bowyer et al. 1995) along with a GIS assessment of shoreline convexity for each latrine site and random site sampled (Albeke et al. 2010). We will also examine spatial and temporal patterns in harvest intensity and distribution similar to analyses for wolverine (*Gulo gulo*) populations in Alaska reported by Golden et al. (2007).

RESULTS AND DISCUSSION

2009 DENSITY ESTIMATION

Among the 60 sites sampled during the 10-day sampling period in June 2009, we counted nearly 2000 fresh scats (Table 1). Of those scats, we collected 787 of the freshest for DNA analysis. The mean number of all fresh scats/site/day counted was 2.9 and collected was 1.2. Lower Passage produced the highest average counts and collections of fresh scats while Eleanor Island produced the lowest (Table 1). Although counts among groups were comparable, they differed by day ($F = 1.65$; $P = 0.21$; df = 2,32; Figure 6, Table 2).

Table 1. River otter scats counted and collected for DNA analysis among latrine sites (n) among areas in the northern Knight Island Archipelago, Prince William Sound, Alaska, 3–13 June 2009.

		Fresh scats (scats/site/day)		
Area	**n**	**Counted**	**Collected**	**Total**
Eleanor	11	274 (0.46)	217 (0.36)	491 (0.82)
Herring	30	384 (0.64)	227 (0.38)	611 (1.02)
Lower Passage	19	495 (0.83)	343 (0.57)	838 (1.40)
Total	60	1153 (1.92)	787 (1.31)	1940 (3.23)

The number of scats collected per day for all sites was generally between 60 and 100, with the exception of the first day (3 June) when 44 were collected and the fifth day (7 June) when 28 were collected (Figure 6). We suspect that the relatively low collection on both days may have been due to ambient temperatures in excess of 12°C (54°F). Warm temperatures may restrict otter movement, thus reducing scat deposition at latrines.

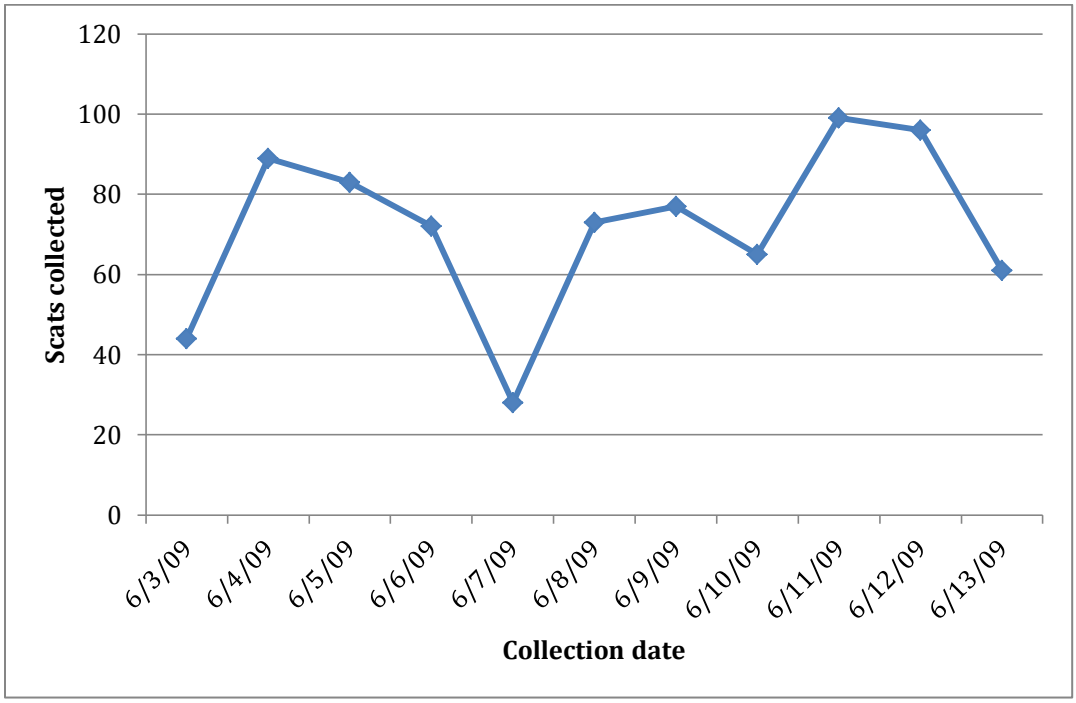

Figure 6. Daily collection of scats among 60 otter latrine sites surveyed for mark-recapture tests in northern Knight Island Archipelago, Prince William Sound, 3–13 June 2009.

Of the 787 samples collected, 129 (or 16.4%) were successfully genotyped with at least 7 of the 8 primers (Lut701, Lut733, Lut801, Lut829, Rio-01, Rio-05, Rio-17, and Rio-19), representing 78 unique individuals (Table 2). Of these, 56 animals were observed only once and 22 were identified between 2 and 5 times. Of the 78 unique individuals observed

in 2009, 15 were also genetically captured in the same area in 2006. Nine of these animals (or 64%) were observed multiple times in 2006. The rest were all identified after 1 July 2006, suggesting they may have been new recruits into the population. The sex ratio of the 2009 sample was 1:1.6 female to male. For 22 animals, the sex was not determined because they amplified as both male and female in separate PCR reactions.

Table 2. Number of river otter fecal samples collected per day and overall in Herring Bay, Lower Passage, and Eleanor Island, Prince William Sound Alaska, June 3-13, 2009. Genotyping success rate was calculated by dividing the number of samples that yielded a complete genotype by the number of samples collected. Average daily temperatures for the collection hours (between 7 AM and 7 PM) were calculated based on hourly measurements obtained from NOAA weather buoy # 46060 (www.noaa.gov).

Date / Area	Number of samples collected	Average daily temperature (°C)	Number of samples genotyped	Success rate
6/3/2009	44	9.6	8	0.18
6/4/2009	89	11.6	13	0.15
6/5/2009	84	10.6	21	0.25
6/6/2009	72	9.5	11	0.15
6/7/2009	28	12.4	2	0.07
6/8/2009	72	10.9	12	0.17
6/9/2009	77	9.9	8	0.10
6/10/2009	65	9.4	13	0.20
6/11/2009	99	10.5	8	0.08
6/12/2009	96	9.8	25	0.26
6/13/2009	61	10.2	8	0.13
Eleanor Island	217		53	0.24
Herring Bay	227		29	0.13
Lower Passage	343		47	0.14
Total	787		129	0.16

Genotyping success, or the number of samples that yielded a complete genotype divided by the number of samples collected, declined with increasing average daily air temperature (Figure 7). The latter was calculated as the average hourly measurements obtained from NOAA weather buoy #46060 (www.noaa.gov) for the fecal collection hours (between 7 AM and 7 PM). There was a negative trend between genotyping success and average daily temperature (r = -0.44, p = 0.17; Figure 7).

Capture and recapture probabilities of otters were modeled separately for days with positive and negative residuals derived from the relationship between genotyping success and average daily air temperature (Figure 7). The effect of average daily air temperature

explained only 19.5% of the variation in genotyping success, probably because additional factors such as the time elapsing between scat deposition and collection, whether the scat contained anal jelly or not, and observer bias affected sample quality. To account for the potential effect of genotyping success, which can affect capture and recapture probabilities, we used the residuals from this regression in developing some of the capture-recapture models (Figure 7). We assumed that positive residuals will translate into high capture probabilities whereas negative residuals will yield low capture probabilities.

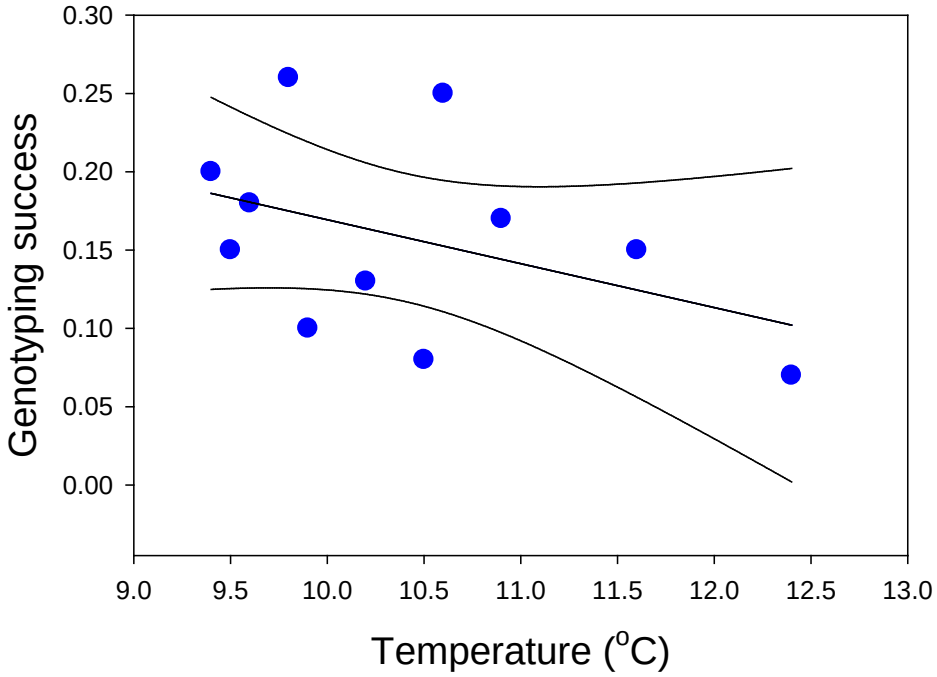

Figure 7. Genotyping success (i.e., the number of samples genotyped divided by the number of samples collected) of river otter fecal samples collected in Herring Bay, Lower Passage, and Eleanor Island, Prince William Sound Alaska, June 3-13, 2009 was negatively related to average daily ambient temperature. The residuals from this regression were used to group capture probabilities in program MARK (i.e., negative residuals modeled as one probability and positive residuals as a second one).

Multilocus genotyping error for the 2009 sample was 0.016, which was lower than the 0.056 calculated for the 2006 dataset. Although allele frequencies in the 2009 sample differed from those of the 2006 one (Table 3), the probability of identity (i.e., the probability that 2 samples with identical genotypes were derived from different individuals) was very low: 1 in 1,091,439 in 2009 and 1 in 3,676,471 in 2006. Observed heterozygosity was slightly lower than expected in the 2009 sample (Table 3).

Table 3. Locus specific and overall measures of allelic richness (AR), and observed (H_O) and expected (H_E) heterozygosity for eight microsatellite loci amplified from river otter feces in Prince William Sound 2006 and 2009. For overall allelic richness, SD values are reported in parenthesis.

	PWS2006				PWS 2009			
Locus	***n***	**AR**	***Ho***	H_E	***n***	**AR**	***Ho***	H_E
Lut-701	131	3	0.59	0.57	76	3	0.58	0.67
Lut-733	131	6	0.65	0.68	78	5	0.70	0.78
Lut-801	131	2	0.36	0.31	74	2	0.44	0.53
Lut-829	130	7	0.75	0.76	74	6	0.69	0.66
Rio-01	131	5	0.74	0.76	76	5	0.53	0.58
Rio-05	100	8	0.83	0.80	71	7	0.75	0.73
Rio-17	131	3	0.59	0.61	78	3	0.30	0.34
Rio-19	131	6	0.69	0.72	78	6	0.77	0.76
Overall		5.00 (2.13)	0.65	0.65		4.63 (1.77)	0.59	0.65

We used closed population models to estimate capture and recapture probabilities and population size. We compared the fit of models including individual heterogeneity with those that did not account for heterogeneity using AICc (Table 4). We repeated this exercise with the full dataset (78 individuals and 11 occasions) as well as a reduced dataset (77 individuals and 10 occasions; Table 4). Because in all cases, models with no heterogeneity had lower AICc and higher weight, we conducted the subsequent analyses using simple closed capture models.

In these analyses, we incrementally reduced the number of occasions from 11 to 6 and estimated population size with several competing models, including those in which we included temperature as a covariate (Table 4). In all cases, the best fit model was the one in which capture and recapture probabilities were the same, but both varied by positive and negative residuals (Figure 7). In all these models, capture and recapture probability on warm days was 0.06 (0.04 – 0.08) and on cool days 0.14 (0.10 – 0.21). The average abundance estimate from the different models was 145 otters (range 131–166; Figure 8). The 95% confidence intervals ranged from 88 – 265 using the data for 6 occasions to 108 – 173 using all 11 occasions (Figure 8), suggesting that when capture and recapture probabilities are low a higher number of occasions will be needed to accurately estimate population size of river otters in this system. For comparison, open population modeling with 5 sampling occasions conducted between the end of May and early July 2006, and abundance estimates produced with a Horvitz-Thompson estimator yielded a population size of 113 otters (95% confidence interval 94–138). The full dataset from 2006 (May to August with 9 sampling occasions) yielded an estimate of 142 otters (106 – 217).

Table 4. Competitive models for closed populations with and without individual heterogeneity. Dataset included 77 individual river otters identified from genotyping of 128 fecal samples collected in 10 sampling occasions in Herring Bay, Lower Passage, and Eleanor Island, Prince William Sound Alaska, 3–12 June 2009. Shown are the top 6 models. Pi is admixture probability, p1 and c1 are capture and recapture probabilities of the "hard to catch animals"; p2 and c2 are capture and recapture probabilities of the "easy to catch animals". Additional models with daily capture and recapture probabilities (p[t],c[t]) ranked lower or did not converge.

Model	AICc	□AICc	AICc Weights	Model Likelihood	Num. Par	Deviance
{pi(1), p1=c1=p2=c2(2,3), N(4)} pi=1}	29.06	0.00	0.84	1.00	3	96.84
{pi(1), p1=c1=p2=c2(temp), N(12)} pi=0}	33.83	4.78	0.08	0.09	11	85.30
{pi(1), p1=c1=p2=c2(t), N(12)} pi=0}	33.83	4.78	0.08	0.09	11	85.30
{pi(1), p1=c1(2), p2=c2(3), N(4)}	46.13	17.07	0.00	0.00	4	111.89
{pi(1), p1=c1(2), p2=c2(3), N(4)} pi = 0	46.47	17.41	0.00	0.00	2	116.26
{pi(1), p1=c1=p2(2), c2(3), N(4)}	46.68	17.63	0.00	0.00	4	112.45

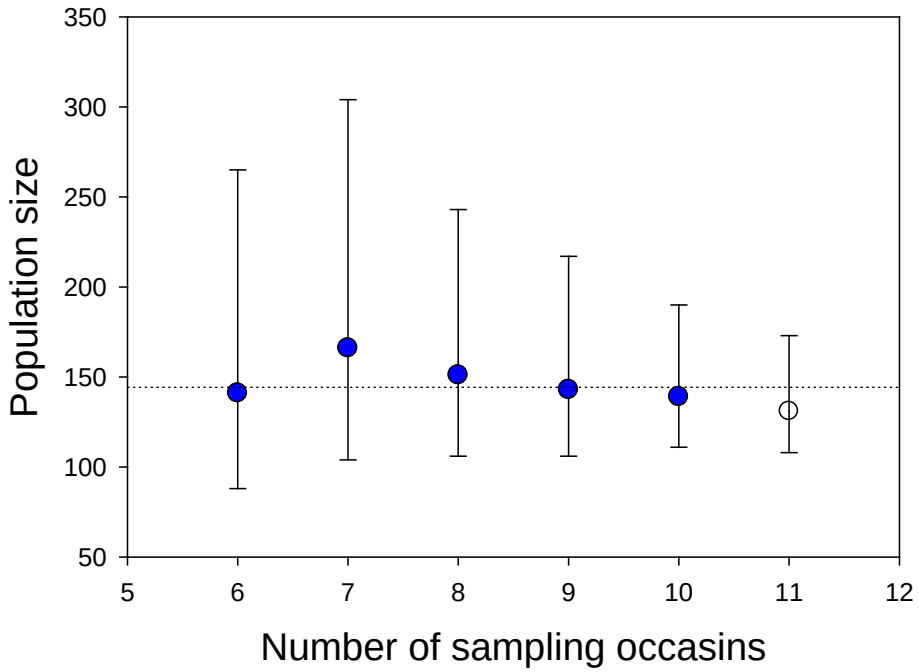

Figure 8. Estimates of population size (± 95% confidence intervals) derived from capture-recapture modeling capture histories derived from river otter fecal samples collected in Herring Bay, Lower Passage, and Eleanor Island, Prince William Sound Alaska, June 3-13, 2009. The number of occasions was incrementally reduced from 11 to 6. Presented are results from the top ranking model in each dataset. The average population estimate for all these models (denoted by the horizontal dashed line) was 145 otters.

The population estimate of 145 (108 – 173) river otters (based on the 11 sampling occasions) for the 110 km of coastline surveyed in 2009, resulted in a density estimate of 132 river otters per 100 km of shoreline. This estimate was substantially higher than an earlier mark-recapture estimate of 36–42 otters/100 km for Herring Bay that was based on radio-isotopes during 1990, approximately one year after the *Exxon Valdez* oil spill (Testa et al. 1994). Our estimate of 132 otters/100 km was also higher than another one for this area in 1997 that was derived by summing individuals identified by DNA microsatellite profiles along with additional live-captured animals (Bowyer et al. 2003). We anticipate improvement in recapture rates and confidence intervals by following changes in field techniques described above for our 2011 surveys.

2010 Latrine Site Survey

We located 231 active latrine sites (Figure 9) along the 340 km of western Prince William Sound coastline surveyed during 21–30 June 2010, resulting in an average density of 68 sites per 100 km. We counted 64 latrine sites in Cochrane Bay, 72 in Eaglek Bay, and 95 in Port Wells. At each new site in each area, we evaluated and recorded habitat features

within a 10-m radius of the main entrance from the water following methods described above (Bowyer et al. 1995, Bowyer et al. 2003).

Figure 9. Latrine sites identified in western Prince William Sound during 21–30 June 2010.

2011 Density Estimation

Among the 3 bays surveyed in 2011, we collected 438 scat samples (daily mean = 54) and 85 hair samples (daily mean = 12; Table 5). Scat collections were higher in total and on average per site for Eaglek Bay versus Esther Passage and Unakwik Inlet, although average hair collection per site was higher in Unakwik Inlet. Daily scat collections for the overall

area ranged between 31 scats on 30 June and 71 scats on 26 June, while hair collections ranged between 10 samples on 27 and 30 June and 18 samples on 29 June (Figure 10).

Table 5. Scat and hair samples collected among 3 areas in Prince William Sound during 25 June–2 July 2011.

	Overall		Esther Passage		Eaglek Bay		Unakwik Inlet	
Collection	**Scats**	**Hair**	**Scats**	**Hair**	**Scats**	**Hair**	**Scats**	**Hair**
Total	438	85	93	21	273	41	72	23
Daily ave.	54.1	12.1	11.6	3.0	34.1	5.9	9.0	3.3
Ave./site	5.5	1.1	3.9	0.9	7.2	1.1	4.2	1.4

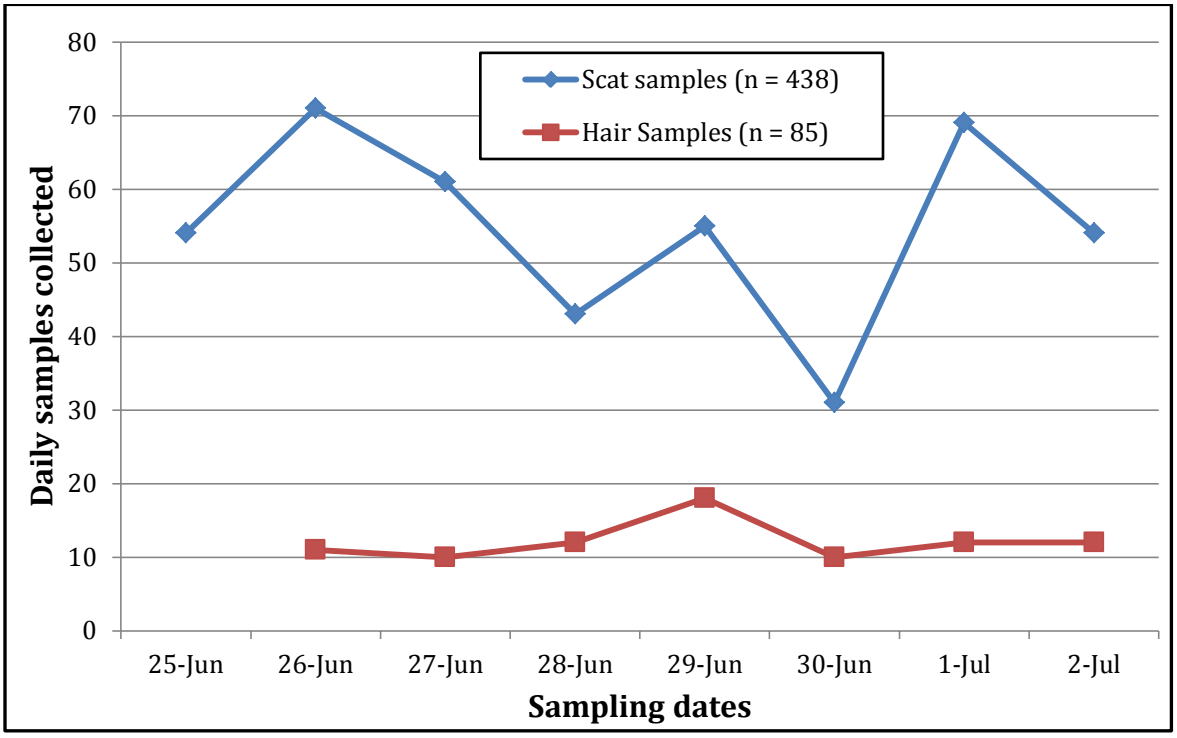

Figure 10. Daily scat and hair samples collected among 79 river otter latrine sites in Prince William Sound, 25 June–2 July 2011.

After returning to Anchorage on 3 July, we refrigerated all scats and then sent them to the laboratory of Dr. Merav Ben-David at the University of Wyoming for processing. We anticipate results from the DNA analysis by June 2012.

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