Measuring associations between river otters: Evaluation of an advanced 'Encounternet' tracking system

Progress Report

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Background

Coastal river otters in Alaska exhibit a plastic social system, where individuals can range from solitary to predominantly social. Social otters spend over 50% of the time in the company of conspecifics. Previous radiotelemetry results indicate that females are usually solitary, whereas males associate more often. The main factor driving river otter sociality appears to be cooperative foraging on schooling pelagic fish. According to this line of evidence, social otters gain better access to high-quality patches of prey, and therefore can derive energetic benefits from living in groups (Blundell et al. 2002, 2004). This is supported by the investigation of river otter diets, indicating that females feed mainly on intertidal and demersal fishes, while pelagic fishes dominate male diets (Blundell et al. 2002). Through their social communication, river otters transport large quantities of marine-derived nutrients to their terrestrial latrines. These nutrients can influence plant growth and community composition (Ben-David et al. 2005, Roe et al. 2010).

Recently, Albeke and colleagues (*in prep*) modeled the response of coastal river otters to declines in abundance of pelagic schooling fishes in the Gulf of Alaska, mimicking predictions of the effects of climate change. Albeke et al. (*in prep*) employed an individual-based spatially-explicit modeling framework and used information on abundance, movement patterns, activity levels and gender differences in consumption of pelagic fishes from previous work (Ben-David et al. 2005, Bowyer et al. 2003, Larsen 1984). These models included no explicit benefits of or constraints on sociality, yet this variable emerged as an important property of the model with males exhibiting a higher degree of sociality than females. More importantly, model results suggested that the time river otters spend in social groups significantly declines with the reduction in availability of schooling fishes. Empirical data on river otter sociality, if incorporated into these models, could substantially aid in assessing the abundance of schooling fishes in various locations in coastal Alaska and elsewhere.

Since the Exxon Valdez Oil Spill in 1989, studies and monitoring of river otter populations in Southcentral Alaska have been conducted. Following the designation of river otters as an ecosystem “vital sign” by the Southwest Alaska Network (SWAN) of National Parks, non-invasive genetic sampling protocols have been developed to estimate density and genetic structure (Ben-David & Golden 2009, Golden et al. 2011, Seymour et al. 2012). There is, however, limited knowledge of the fine-scale association patterns between individuals in these populations. In view of the potential effects of climate change on schooling pelagic fishes and the ecosystem implications of declining river otter sociality, we are interested in quantifying the proportion of time coastal river otters spend in social groups and the relative roles of individuals within these social networks. In addition, fine-scale spatial and temporal information on activity and latrine use by river otters can provide crucial information on these ecosystem processes. Here, we present preliminary results obtained from an evaluation of a novel tracking system, used for the first time to assess the frequency of associations among river otters in Kenai Fjords National Park, Alaska.

Methods

We used small boats to survey the coastline of Aialik Bay, Kenai Fjords National Park, for river otter latrine sites in 20–21 June 2012. During this pre-survey period we detected 36 active latrine sites along the coast (Figure 1). From the latrines found, we selected sites for trapping using two criteria: (1) activity as revealed by fresh scats found within each site; and (2) suitability for trapping, taking into account the site layout and the safety of trapped animals. We set 31 Sleepy Creek #11 leg-hold traps in 18 selected sites (Figure 2) following procedures described in Blundell et al. (1999). Traps were equipped with transmitters for remote and continuous monitoring. In addition, traps were visually checked every 24 hours.

We anesthetized captured animals using pneumatically-projected darts loaded with Telazol, at a dose of 9 mg/kg body mass (Bowyer et al. 2003). We then weighed and measured each otter for morphometrics and collected blood samples from the jugular vein. In addition, we attached an Encounternet tag unit (Burtsoft Consulting, Portland, OR) to each adult. We glued the Encounternet tags to the hair on the back approximately 10 cm dorsal to the scapulae, using a 5-minute Epoxy (Figure 3). The Encounternet tags use wireless technology to record the presence of other tags in their proximity and save this information onboard unit memory. We set the detection range of the tags to 5 meters and the sampling frequency to 5 seconds. The Encounternet tracking system is also composed of base units and a master node. Base units are static units, placed at locations where animals are likely to visit frequently. Base units detect electronic signals from tag units, and in addition to recording tag unit location, they are programmed to download the encounter records which were saved onboard the tags. The master unit controls the system by setting unit configurations and downloading data from base units.

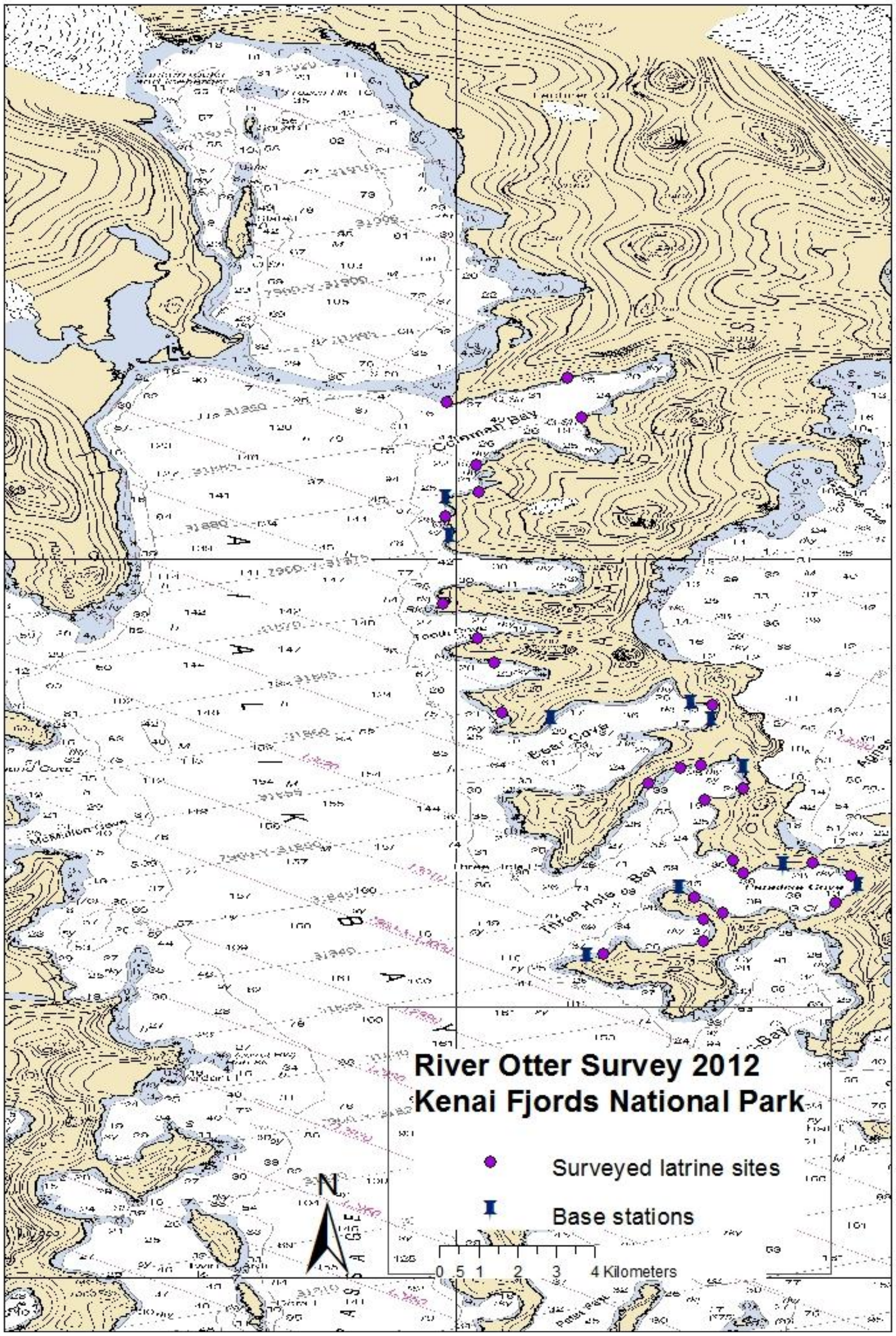


Figure 1. Map of study area, within Aialik Bay, Kenai Fjords National Park, Alaska, where a survey of river otter latrine sites and trial of the tracking system were conducted in June-July 2012. Surveyed latrine sites are denoted with purple circles and sites with base units with blue pins.

We deployed 10 base units in strategic latrine sites (Figure 1) in Aialik Bay. We selected latrine sites based on river otter activity, while attempting to achieve a uniform distribution of these units along the coastal area surveyed. We wired the base units to trees approximately 2 meters above the ground (Figure 4) to achieve maximal reception range (circa 20 m, according to manufacturer specifications). During the collection period, data were downloaded three times (five and nine days following deployment and upon removal). We replaced the base unit batteries nine days after deployment. We collected the base units 20 days after trapping and sampling efforts were concluded.

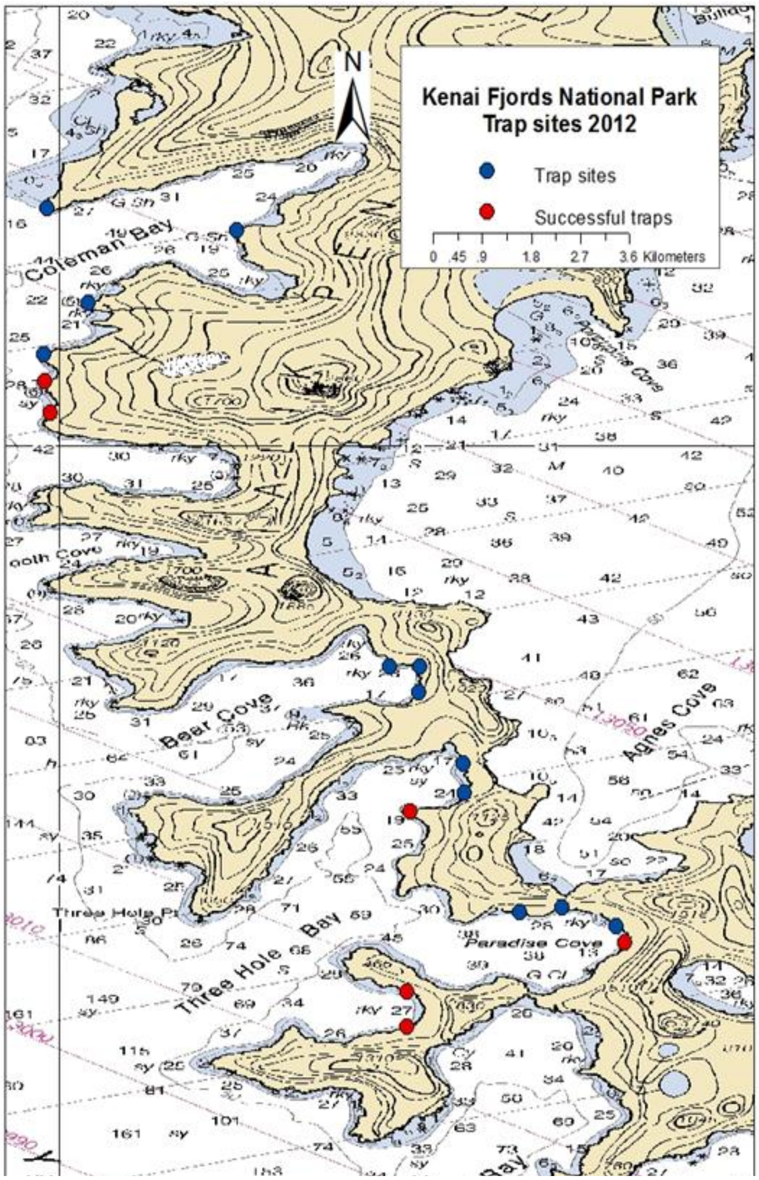


Figure 2. Locations of successful and unsuccessful trap sites used to capture river otters for the attachment of Encounternet tracking units. Research was conducted in Kenai Fjords National Park, Alaska, in June - July 2012.

Figure 3. An Encounternet tag glued to the back of an adult river otter in Aialik Bay, Kenai Fjords National Park on 25 June 2012. The sedated otters were placed in a wooden, self-release recovery box.

Figure 4. A base station (# 206) attached to a tree at a river otter latrine site in Aialik Bay, Kenai Fjords National Park on June -July 2012.

We downloaded and analyzed encounters recorded among tagged otters and their individual detections at base stations on July 27th. Events recorded within less than 15 minute intervals were considered single encounters or detection events. We constructed two association matrices, one based on the total number of encounters and one based on the average of minutes per day the animals spent together. We chose the minutes per day matrix since it represented more accurately the time animals spent together. For each individual, we calculated strength centrality, a social network measure based on the summation of the immediate associations of an individual within the network (Krause et al. 2009).

Concurrently with trapping, we monitored fecal deposition rate and collected fresh feces for genetic analyses at the 34 latrine sites identified during our pre-survey period. Fecal collection was conducted for 6 consecutive days, between June 27 and July 2. Each selected latrine site was surveyed for fresh river otter feces. To ensure that we did not count feces twice, we labeled all existing fecal matter with glitter. Fresh feces (i.e., those without glitter) that contained anal jellies (a slimy substance excreted from the anal gland with high value for genotyping; Ben-David & Golden 2009) were collected in 100% ethanol and preserved on ice.

Preliminary results

Trapping lasted 11 days (June 22 – July 2) for a total effort of 222 trap days. We recorded 16 trap failures for various reasons, including the involuntary stepping of hikers into traps. The total failure rate was 0.066, comparable to results from Blundell et al. (1999), where leg-hold trap malfunction rate was 0.065. Of the 18 trapped latrine sites, only 6 were successful capturing otters, with 3 recording multiple captures (Figure 2). We captured 8 adult river otters, including 5 males and 3 females. In addition, 1 male pup was captured. The pup was examined, weighed and released without further treatment. Capture success rate was 0.042, again similar to previous values of 0.048 (Blundell et al. 1999). All adult otters appeared in good body condition. Male weight was on average 9.46 (± 1.27) kg and female weight 7.86 (± 0.55) kg (Table 1).

Of the 8 instrumented animals, 7 were subsequently detected at latrine sites. River otters were tracked for a total of 67 days, amounting to 12,069 records in the 10 base stations. The rate of detection per day varied considerably, and averaged between 0 and 557.5 per individual. Of the 3 females, only 2 were subsequently detected once by base stations and the maximal tracking period for each was one day, suggesting either unit loss or avoidance of monitored latrine sites. Among the tracked males there was substantial variance in detectability, with 3 males detected in the southern portion of the tracking range (Figure 5) and exhibiting high detection rates. The 2 remaining males were less frequently detected, visiting only two monitored latrines in the northern edge of the study area, suggesting that their home ranges barely overlapped with our study area (Table 2, Figure 5).

Table 1. Morphometric measurements of 8 adult and 1 pup river otters captured in Aialik Bay, Kenai Fjords National Park, June 22- July 2, 2012.

ID	Capture date	Sex	Age	Body length (cm)	Tail length (cm)	Mass (kg)
12	07/01	M	Yearling	79.5	46.5	8.12
14	07/01	M	Adult	76.6	59.5	10.98
15	06/26	M	Adult	78	44	8.71
16	07/01	M	Adult	76	47	10.57
17	06/25	M	Adult	75.8	43.4	8.93
18	06/26	F	Adult	76	47	8.25
19	06/23	F	Adult	-	-	7.48
20	06/23	F	Adult	-	-	-
21	06/24	M	Pup	42.5	27	2.08

Encounters were recorded for all 5 males. The total number of encounters recorded was 1,337, resulting in 122 15-minute interval interactions. These encounters revealed interactions among 4 dyads, suggesting that the animals tagged belong to two distinct groups (Figure 6). The vast majority of encounters were recorded among the 3 males inhabiting Three Holes Bay (117, Table 3). When the days of overlap were taken into account, the number of encounters and average interaction length by individuals 14 and 16 were considerably lower compared to the other three dyads (Table 4). No encounters were recorded for any of 3 females instrumented with tag units.

From the limited network information, it appears the yearling male (ID 12) was less connected to the other two adult males (Figure 6). The two remaining males, 14 and 16, recorded a sparse number of associations, largely because their home range barely overlapped with the study area. A larger sample size will be needed for robust inference on social patterns using network theory.

Table 2. Tracking periods, number of detections and the number of used latrines for 8 adult river otters captured and instrumented with an Encounternet tag in Aialik Bay, Kenai Fjords National Park, Alaska, in July 2012.

ID	Sex	Capture date	Last detected	Days tracked	No. detections	Detections per day	Used latrines	Base station ID
12	M	07/01	07/18	17	2520	148.2	8	202 203 204 206 207 208 209 210
14	M	07/01	07/05	5	6	1.2	2	201 205
15	M	06/26	07/09	15	8362	557.5	8	202 203 204 206 207 208 209 210
16	M	07/01	07/10	9	137	15.2	2	201 205
17	M	06/25	07/13	19	1028	54.1	8	202 203 204 206 207 208 209 210
18	F	06/26	06/27	1	15	15.0	1	209
19	F	06/23	06/24	1	1	1.0	1	201
20	F	06/23	06/23	0	0	0.0	0	NA
Total				67	12069	113.18		

For the 3 males for which there was significant overlap between home range and the area covered by base stations (Figure 5), it was possible to calculate the time spent in specific den or resting sites. For example, of 35 detections in latrine sites for otter 15, six lasted over one hour. Individual 15 spent periods of 10, 12 and 15 hours at different latrine sites, suggesting that it was resting or sleeping during these periods (Figure 7). From these data it is also clear that the sampled otters used other latrines for resting and denning as otter 15 visited the monitored latrines for only short periods between June 29th and July 6th.

Table 3. Tracking period and encounter data summary for river otters in Kenai Fjords National Park, Alaska, in July 2012.

ID	Days tracked	Total encounters	15-minute interval encounters	Number of individuals Encountered
12	17	560	25	2
15	15	862	100	2
16	9	31	5	1
14	5	31	5	1
17	19	719	108	2

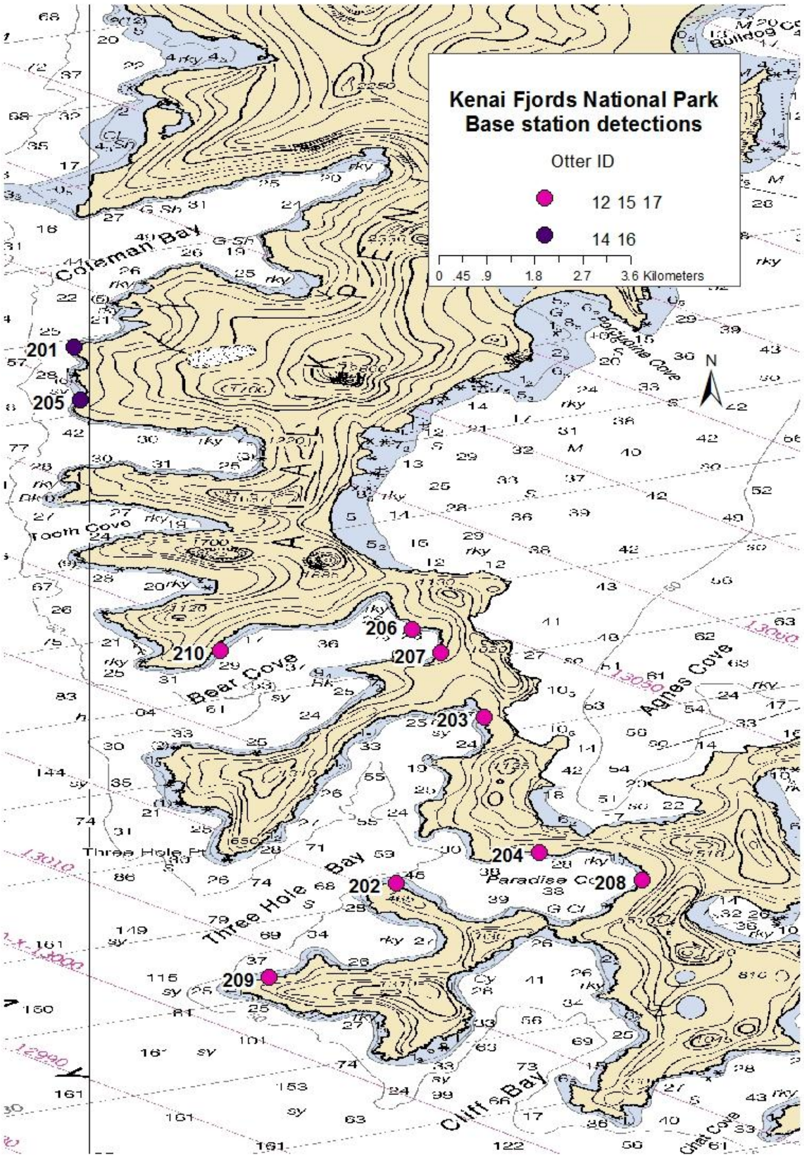


Figure 5. Location of latrines with detections of individual river otters in Aialik Bay, Kenai Fjords National Park, Alaska, June- July 2012. Detections reflect the separation in space use between two groups of otters composed of at least 2 and 3 males.

The 10 base stations deployed within the research area remained active for an average of 24.4 ± 3.1 (SE) days. All base stations recorded river otter detections, however, the number of detections varied considerably between units (Figure 7, Table 5). One of the base stations (201) failed prior to battery replacement, approximately 9 days after deployment. Following battery replacement, the minimal recording time for all base stations was 12 days.

Otter activity surveys, using fresh scat counts at latrine sites monitored daily over six days, demonstrated a steady decline in river otter activity. In addition, there was a moderate decline in latrine visits registered in base stations (Figure 8). New scat counts and detected latrine visits were highly correlated (spearman $\rho = 0.93$, $p = 0.03$). These observations suggest that there might be a negative effect of trapping on otter scent marking activities at latrines.

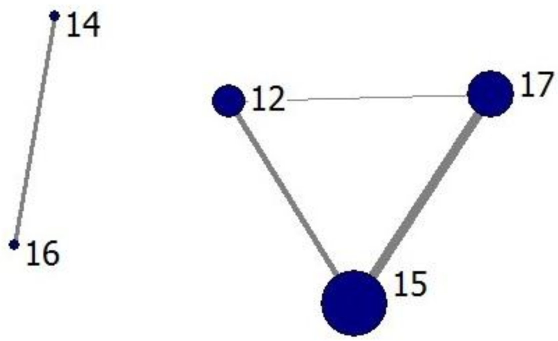


Figure 6. Network diagram depicting associations of tagged male river otters in two groups in July 2012 in Kenai Fjords National Park, Alaska. Circle sizes are proportional to centrality of individuals and the thickness of the lines represent the degree of interactions. Note that otter 12, a yearling, is less connected compared to the other 2 members of the group.

Table 4. Tracking period, quantity and average length of encounters for dyads of river otters in Kenai Fjords National Park, Alaska, in July 2012.

Dyad	Days overlap	Total encounters	15-minute interval encounters	Average length of encounters (min ± SE)	Total minutes	Minutes per day
12 15	9	351	8	263 (305.2)	2104	233.8
12 17	13	208	17	77 (162.6)	1309	100.7
15 17	14	511	92	52 (100)	4784	341.7
14 16	5	31	5	35 (49.9)	175	35.0

Discussion

We were able to obtain reliable association data for 5 male river otters. The Encounternet system we employed revealed fine-scale associations among the tracked animals over a limited period of time, providing high-resolution information on the length and frequency of animal encounters and events of fusion and fission within the one river otter group. All 5 males had encounters with other animals, while all 3 females were rarely detected following tagging. These results could be a consequence of tag loss by the females.

However, since results were similar for all 3 females, this seems unlikely. Alternatively, females, who may have had young pups during our tracking, could have been avoiding those latrine sites that were heavily used by males, which were also the sites where we selected to deploy base stations. Overall, the lack of associations demonstrated by females compared to males, support evidence from radiotelemetry demonstrating high sociality among males and lower frequency associations for females (Blundell et al. 2002, 2004).

Table 5. Summary of river otter detections in 10 base stations deployed in Aialik Bay, Kenai Fiords National Park, Alaska, June - July 2012.

Unit ID	Tracking days	Total detections	Total activity
201	22	11	3
202	21	1032	2
203	23	156	35
204	33	6838	31
205	25	136	3
206	24	206	11
207	25	3460	25
208	24	208	10
209	24	118	9
210	23	64	3

Within the only group for which we could describe association patterns, the 2 adults had more frequent associations than the third individual, which was a yearling. While caution should be used drawing inference from this small sample size, this pattern is apparently opposed to results from previous work, showing that juvenile males were responsible for maintaining the social connections in river otter groups during the mating season (Hansen et al. 2009). In that captive study, adult social withdrawal was accentuated during the breeding season when juveniles maintained their association patterns (Hansen et al. 2009). Following the mating season, adult males exhibited higher levels of interactions, and occupied more central positions in the network than juveniles (Hansen et al. 2009). Our study was conducted nearly a month after the end of the mating season, which better fits the latter patterns described by Hansen et al. (2009). A larger sample size will be necessary to draw firm conclusions on the effects of seasonality on male river otter associations in the wild.

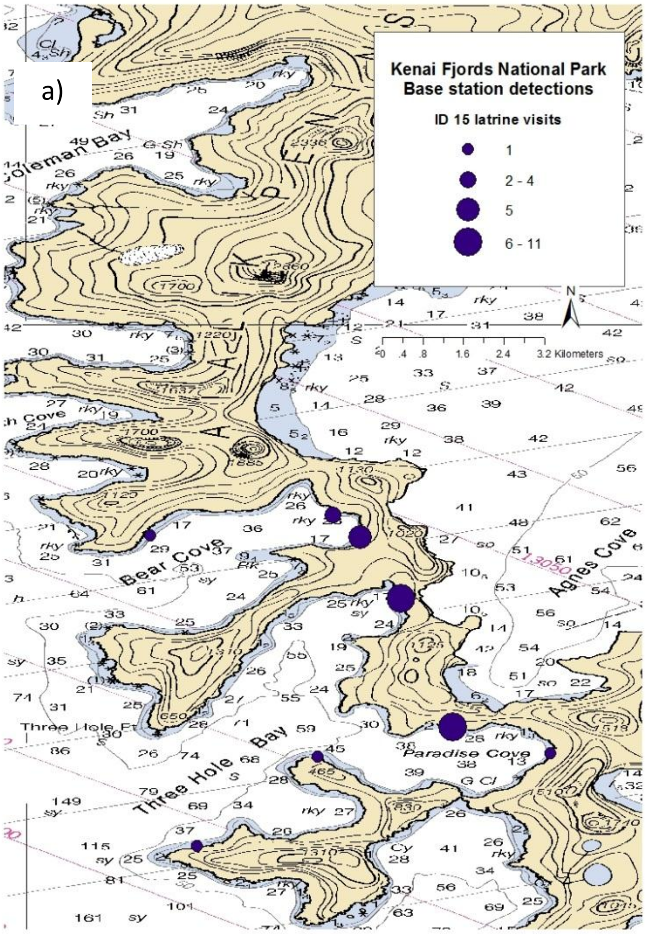
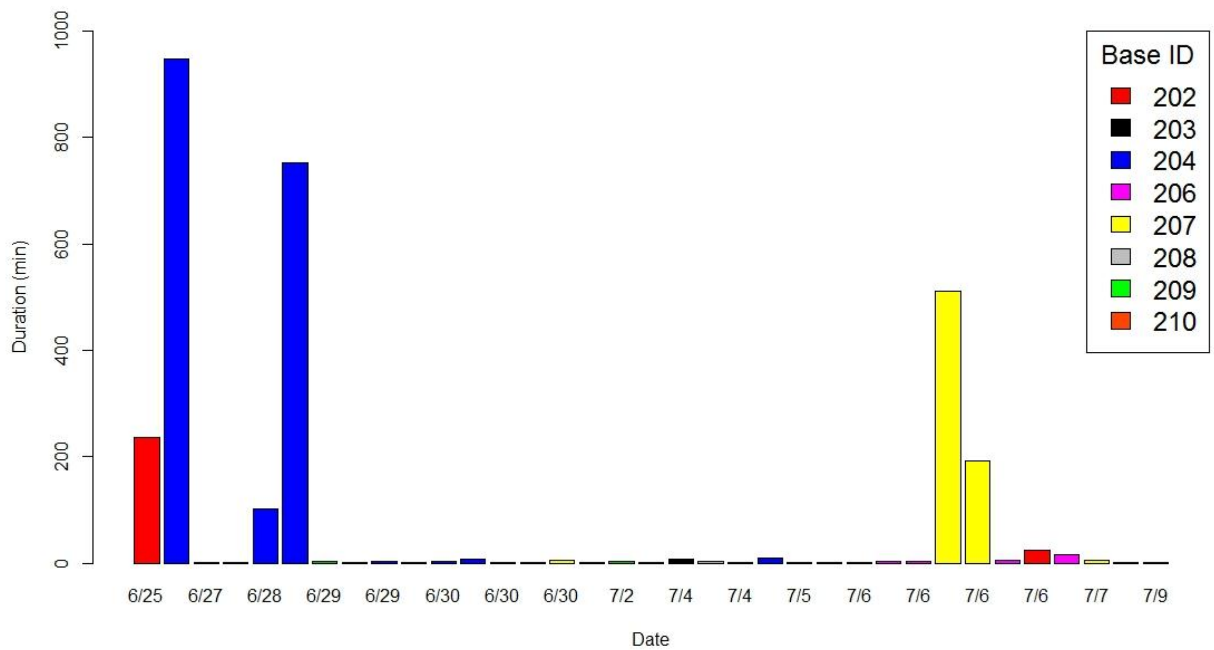


Figure 7. a) Locations where river otter 15 was detected during 15 days of tracking in Aialik Bay, Kenai Fjords National Park, Alaska, June - July 2012. Circle sizes are proportional to the number of visits to each site. b) Bar plot showing the duration of time spent by individual 15 in different locations during the tracking period (total of 35 detections).

b)



In addition to the social associations among male river otters, the Encounternet system provided repeated detections of individuals in various latrine sites. These data enabled us to assess the range occupied by these animals in the absence of geo-locating devices. In addition, it allowed us to quantify the frequency of use of den or latrine sites within this occupied range and calculate the amount of time spent at each site. This increases the resolution of information on river otter scent-marking behavior, available so far from daily fecal counts at latrines (Ben-David and Golden 2009), or on a longer time frame from radiotracking (Ben David et al. 2005). Because the frequency and magnitude of latrine use by river otters has ecosystem-wide implications (Ben-David et al. 1998, 2005, Roe et al. 2010), high-accuracy measurement of this activity has considerable conservation value.

If available for a larger number of individuals, the type of information obtained with this advanced, relatively cost-effective tracking system may yield reliable assessment of group size and social cohesiveness in coastal river otter populations. In addition to the recently developed non-invasive density estimation techniques for this important indicator species (Ben-David and Golden 2009), this method could be a promising management tool, providing indications of ecological system stability and responses to climatic change.

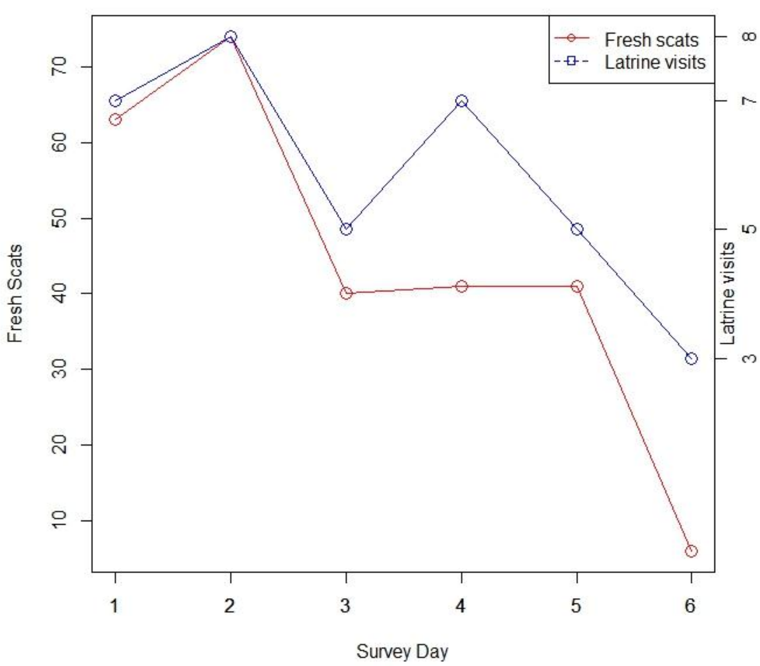


Figure 8. River otter activity measured by fresh scat counts and latrine visits, as detected by base stations in Aialik Bay, Kenai Fjords National Park, Alaska, June - July 2012. Note a decline in both measures of activity, possibly as a consequence of the use of these latrine sites for trapping.

Future prospects

The coastal area used for trapping in this specific study was relatively small due to logistical constraints and the limited signs of activity in adjacent areas of Aialik Bay. In addition, there were gaps within the trapping area as a result of sparseness of latrine sites (Figures 1, 4) resulting from inadequate habitat quality. It appears from fresh scat counts that river otter density in Kenai Fjords may be lower compared to other Alaska coastal areas. Individual identification from DNA extracted from the feces we collected will provide support for this initial assessment. However, for a better assessment of river otter social behavior with an Encounternet system, this experiment should be undertaken in an area with a more uniform spread of latrines and a density of animals that enables the more robust measurement of interactions (e.g. Herring Bay or Eaglek Bay in Prince William Sound).

We obtained a remarkably low amount of data from tagged female river otters. Females were hardly detected at latrine sites, and showed no association with the continuously tracked males. While the ultimate goal of this project is to quantify river otter sociality, it could be interesting to investigate female associations and latrine use. Previous research has demonstrated that females occasionally join male groups in foraging forays for schooling fish (Blundell et al. 2002) and use a larger number of latrines with lower intensity (Ben-David et al. 2005). A more dense spread of base stations along the coastline, including sites that show lower activity, could enable us to obtain more detections of females and measure their latrine visits. If resources are limited and the number of tagged animals is limited, however, we should favor attaching tracking units to males over females.

The spread of base stations in the southern part of the research area was adequate and provided successful results. The 3 males that had home ranges within this area were repeatedly detected in all of the 8 relevant sites. Two additional males were rarely detected following their capture. These two males were only captured on the 10^{th} trapping day. Therefore, the two base stations where these males were detected may be in a rarely used part of their range. We suspect that an increased coverage of a larger portion of coastal area, especially northward, with additional base stations could have provided further detections of these males.

In addition to an increased number of base stations, cameras in monitored sites could provide valuable complementary information to the data collected from the Encounternet system. Animals detected by cameras could enable us to obtain a more accurate assessment of group size, and unmarked animals could be incorporated into the measurement of sociality increasing data cohesiveness and sample size. The total number of marked and unmarked individuals an otter is observed with will provide an additional measure of social connectivity for each animal (e.g. Templeton et al. 2012).

Because there was some indication that trapping at latrine sites affected river otter activity, it is not advisable to concurrently conduct density estimates from fecal DNA analyses and capture efforts in the future. One possible course of action could be to first perform density estimate surveys, while habituating river otters to repeated human presence at latrine sites and obtaining a better assessment of otter activity over several days. Following the survey, base stations could be positioned and trapping could commence with better knowledge of latrine use in the area. The capture and multiple detections of animals by base units, in conjunction with fecal sampling, could add to the accuracy of density estimation based on mark-recapture models by increasing recapture rate and providing better information on otter presence at latrines. Density estimates could, in turn, aid methods for assessing social interactions by providing information on the proportion of marked animals within the research area.

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References

Albeke, S.E., Nibbelink, N.P. & Ben-Diavid, M. (In preparation). Modeling behavior of coastal river otter (*Lontra Canadensis*) in response to prey availability in Prince William Sound, Alaska: a spatially-explicit individual based approach. Ecological Applications.

Ben-David, M., Bowyer, R.T., Duffy, L.K., Roby, D.D. & Schell, D.M. (1998). Social behavior and ecosystem processes: river otter latrines and nutrient dynamics of terrestrial vegetation. Ecology 79, 2567–2571.

Ben-David, M., Blundell, G. M., Kern, J. W., Maier, J.A.K., Brown, E. D. & Jewett, S. C. (2005) Communication in river otters: creation of variable resource sheds for terrestrial communities. Ecology 86, 1331-1345.

Ben-David M. & Golden, H.N. (2009). River otters (*Lontra canadensis*) in southcentral Alaska: distribution, relative abundance, and minimum population size based on coastal latrine site surveys. SWAN I&M program report, National Park Service. Anchorage, AK. 43 pg.

Blundell, G.M., Kern, J.W., Bowyer, R.T, & Duffy, L.K. (1999) Capturing river otters: a comparison of Hancock and leg-hold traps. Wildlife Society Bulletin 27, 184-192.

Blundell, G. M., Ben-David, M. & Bowyer, R. T. (2002). Sociality in river otters: cooperative foraging or reproductive strategies? Behavioral Ecology 13, 134-141.

Blundell, G. M., Ben-David, M., Groves, P., Bowyer, R. T. & Geffen, E. (2004). Kinship and sociality in coastal river otters: are they related? Behavioral Ecology 15, 705-714.

Bowyer, R. T., Blundell, G. M., Ben-David, M., Jewett, S. C., Dean, T. A. & Duffy, L. K. (2003). Effects of the Exxon Valdez oil spill on river otters: injury and recovery of a sentinel species. Wildlife Monographs 153, 1-53.

Golden, H. N., Ben-David, M. & Crowley, D. (2011). Assessment of the river otter population in Prince William Sound. Final Report. USDA Forest Service – Chugach National Forest. 23 Pp.

Hansen, H., McDonald, D.B., Groves, P., Maier, J.E.K. & Ben-David, M. (2009). Social networks and the formation and maintenance of river otter groups. Ethology 115, 384-396.

Krause, J., Lusseau, D. & James, R. (2009). Animal social networks: An introduction. Behavioral Ecology and Sociobiology 63, 967-973.

Krause, J.,Wilson, A. & Croft, D.P. (2011). New technology facilitates the study of social networks. Trends in Ecology & Evolution 26, 5–6.

Larsen, D. N. (1984). Feeding habits of river otters in coastal southeastern Alaska. Journal of Wildlife Management 48, 1446–1452.

Roe, A. M, Meyer, C. B., Nibbelink, N. P. & Ben-David, M. (2010). Differential tree and shrub production in response to fertilization and disturbance by coastal river otters in Alaska. Ecology 91, 3177-3188.

Seymour, M.S., Ott, K.E., Guertin, D.A., Golden, H.N., McDonald, D.B., & Ben-David. M. (2012). Early Holocene glacial retreat isolated populations of river otters (*Lontra canadensis*) along the Alaskan coast. Canadian Journal of Zoology, 90, 1136-1148, 10.1139/z2012-082.

Templeton, C.N., Reed, V.A., Campbell S.E. & Beecher, M.D. (2012). Spatial movements and social networks in juvenile male song sparrows. Behavioral Ecology 23, 141–152.

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