Wildlife Research Final Report

Spatial relationships, movements, and abundance of brown bears on the southern Mainland Coast of Southeast Alaska

Rodney W. Flynn, Stephen B. Lewis, LaVern R. Beier, and Grey W. Pendleton

June 2010

Alaska Department of Fish and Game **Division of Wildlife Conservation**

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This Wildlife Research Report was approved for publication by Rod Flynn, Regional Research Coordinator in Region I for the Division of Wildlife Conservation.

This document should be cited as:

Flynn, R. W., S. B. Lewis, L. R. Beier, and G. W. Pendleton. 2010. Spatial relationships, movements, and abundance of brown bears on the southern Mainland Coast of Southeast Alaska. Alaska Department of Fish and Game, Division of Wildlife Conservation, Wildlife Research Final Report. Juneau, AK.

This research and publication of this manuscipt were financed by the U.S. Fish and Wildlife Service, Juneau Field Office, Juneau, Alaska as part of their Tongass Monitoring Program (Grant #701815G364), the U.S. Forest Service, Tongass National Forest, Ketchikan (#AG-0116-P-05-006), and the Alaska Department of Fish and Game, Douglas (Federal Aid in Wildlife Restoration Grant No. W-33-8, Project No. 4.36).

Cover Photo: Radiocollared male brown bear #508 along the east Bradfield River.
Photos by and courtesy of LaVern Beier.

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ACKNOWLEDGEMENTS

This project was primarily funded by the U.S. Fish and Wildlife Service, Juneau Field Office, Juneau, Alaska as part of their Tongass Monitoring Program (Grant #701815G364). Additional funding was provided by the U.S. Forest Service, Tongass National Forest, Ketchikan (#AG-0116-P-05-006) and the Alaska Department of Fish and Game, Douglas (Federal Aid in Wildlife Restoration Grant No. W-33-8, Project No. 4.36). Kim Hastings arranged for the U.S. Fish and Wildlife Service grant, and Linn Shipley and Carol Seitz Warmuth assisted with obtaining the U.S. Forest Service funding. Field offices of the Alaska Department of Fish and Game in Ketchikan and Petersburg provided staff and logistical support, including Wildlife Division staff Richard Lowell, Mary Meucci, and Boyd Porter. Red Weller and his Sport Fish field crew provided critical support on the Unuk River. Dan Cushing, Doug Fleming, Jason Wolle, and Jonathan Mollick assisted with the field work. Wally O'Brocta, Temsco Helicopters, piloted the helicopter during the capture and other field work. Dr. David Paetkau, Wildlife Genetics International, contributed many useful insights into the genetics of brown bears and completed the DNA analysis. Garth Mowat shared experiences and information from his study in the Upper Stikine River area.

Chapter 1

INTRODUCTION

Background

Since the beginning of the Tongass Land Management Plan (TLMP) revision process (Sidle and Suring 1986, U.S. Forest Service 1997), brown bears have been considered a wildlife species of high public interest on the Tongass National Forest. Beginning in 1981, the ecology of brown bears was extensively studied on Admiralty and Chichagof Islands (Schoen and Beier 1990, Titus et al. 2000, Flynn et al. 2007). In contrast, little research has been attempted on brown bears along the mainland coast. Recently, the demand for opportunities to hunt and view brown bears has increased on the mainland (Porter 2001, 2003). Thus, an understanding of brown bear ecology on the mainland coast in Southeast Alaska emerged as a research priority (Flynn et al. 2007).

Little basic biological information is available to guide the management of brown bears on the mainland coast of Southeast Alaska; yet evidence suggests that brown bear densities may be much lower on the mainland coast compared with Admiralty, Baranof, and Chichagof islands (Porter 2001, Whitman 2001). Because of concerns with the overharvest of brown bears, a moratorium on the issuance of additional U.S. Forest Service (FS) special use permits for guiding brown bear hunts in Game Management Units 1A and 1B was implemented beginning in Spring 2001 (Porter 2003). If brown bear densities on the mainland coast are substantially lower, greater restrictions on the number of guide/outfitter and big-game hunting permits may be needed. In contrast, larger numbers of bears may allow a greater take. Determining the appropriate number of guide/outfitter special-use or big-game hunting permits can only be made with an adequate knowledge of brown bear numbers, movements, availability, and vulnerably. Increased knowledge on seasonal spatial use and movement patterns would help determine vulnerabilities and provide guidance for the timing and location of activities.

Several potential development projects on mainland southeast Alaska may put brown bears at additional risk. Logging, mining and new roads have been proposed for several mainland areas including a new road connecting Wrangell with British Columbia along the Bradfield River corridor and new mines in the adjacent Stikine River basin of British Columbia. As logging and development expands on the mainland coast, the appropriateness of habitat management for brown bears needs additional evaluation. An increased understanding of seasonal habitat selection, especially during the late summer, will provide better insight into important bear foraging areas and cover requirements on the mainland coast.

During the TLMP Revision, expert panels expressed concern with the long-term population viability of brown bears unless adequate riparian vegetation was maintained, especially in areas with spawning salmon (*Oncorhynchus* spp.) (Swanton et al. 1996, U.S. Forest Service 1997). These panelists strongly recommended that a minimum 150-m, no-harvest buffer be maintained along streams considered important for brown bear foraging (Swanston et al. 1996). Responding to the concerns of the public and expert panels, the TLMP included a forest-wide standard and guideline that requires evaluation of the need for additional protection of important bear foraging sites during project planning (U.S. Forest Service 1997). On Admiralty and Chichagof islands, salmon-spawning streams are numerous and riparian zones provide important habitats for brown bears in Southeast Alaska (Schoen and Beier 1990, Schoen et al 1994, Titus et al. 2000, Flynn et al. 2007). During the late summer, most brown bears concentrate in riparian areas with spawning salmon (Titus and Beier 1999). On the Kenai Peninsula, salmon played a key role in the accumulation of lipid stores of female brown bears (Hildebrand et al. 1999a). Brown bear populations with access to abundant, spawning salmon were larger and more productive (Hildebrand et al. 1999b). The role of anadromous salmon and the transport of these salmon by bears into riparian ecosystems have recently been recognized (Willson and Halupka 1995). Hildebrand et al. (1999c) found that brown bears were important vectors of salmon-derived N into riparian systems, and the deposition of salmon-derived N was highly correlated with bear spatial patterns.

The availability of salmon-spawning streams suitable for brown bear foraging may be limited on the mainland coast because of the large flow of many streams and glacial sediments in the streams. Many streams on the mainland coast originate from glaciers. Glacial sediments limit the suitability of streams for salmon spawning. Also, glacial sediments limit visibility of salmon to the bears.

Current brown bear research has incorporated several new technologies (Flynn et al. 2007) to tackle old, difficult problems. The emergence of Global Positioning System (GPS) radiocollars has allowed the collection of precise and frequent location information, even from remote areas (Flynn et al. 2007). The development of self-release mechanisms reduces the difficulty of retrieving the collars, especially in remote areas. The collars can be programmed to release when the animals are likely to be near streams during the early fall. The development of non-invasive, genetic sampling techniques, used in conjunction with mark-recapture models, has greatly increased our ability to estimate brown bear abundance (Woods et al. 1999, Mowat and Strobeck 2000, Mowat et al. 2005). DNA markers can be used to accurately identify individual bears (Paetkau 2003). Also, the species of bear can be easily determined in areas where the ranges of black and brown bears overlap. Small amounts of DNA can be easily collected from hair snagged at desired locations (Beier et al. 2005). Individual bear capture histories can be used to estimate the number of bears (Mowat and Strobeck 2000). In addition, capture histories provide data on individual movements among nearby areas.

This research was designed to investigate the spatial relationships, movements, and abundance of brown bears along a portion of the mainland coast in Southeast Alaska. The specific objectives were as follows: 1) to determine spatial relationships and seasonal movements of brown bears along a portion of the mainland coast including transboundary movement of brown bears; and 2) to estimate the number of brown bears in a portion of the southern mainland coast during late summer.

This report has been organized into 3 chapters. The first chapter provides an introduction to the entire report. The subsequent chapters have been written as stand-alone manuscripts suitable for publication. In Chapter 2, we present information on movements and spatial relationships of brown bears collected during the course of the study primarily by the deployment of GPS radiocollars. The third chapter provides an estimate of abundance for the Bradfield study area in 2005 and 2006 and the Unuk River study area in 2007 using a DNA-based mark-recapture approach. Also, we were able to incorporate additional information on transboundary movements by using information on bears marked in Canada by collaborators.

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Chapter 2

SPATIAL RELATIONSHIPS OF BROWN BEARS ON THE SOUTHERN MAINLAND COAST OF SOUTHEAST ALASKA

INTRODUCTION

Brown bears (*Ursus arctos*) have long been considered a wildlife species of high public interest in Southeast Alaska. Although brown bears have been studied extensively on Admiralty and Chichagof islands (Schoen and Beier 1990, Titus et al. 2000, Flynn et al. 2007), little research has been attempted on brown bears along the mainland coast. Thus, little biological information is available to guide management. As demand for brown bear hunting and viewing have increased on Admiralty, Baranof, and Chichagof islands (ABC), users have looked to opportunities to hunt and view brown bears on the mainland (Porter 2001, 2003). Because of increased demand and concerns with the overharvest of brown bears, a moratorium on the issuance of additional U.S. Forest Service (FS) special use permits for guiding brown bear hunts in Game Management Units 1A and 1B was implemented beginning in Spring 2001 (Porter 2003). Determining the appropriate number of guide/outfitter special-use or big-game hunting permits can only be made with an adequate knowledge of brown bear numbers, movements, availability, and vulnerably. Movements across the international boundary cause additional management complications and may require more collaboration between wildlife and land management agencies. Increased knowledge on seasonal spatial use and movement patterns would help determine vulnerabilities and provide guidance for the timing and location of activities.

Several potential development projects on mainland southeast Alaska may put brown bears at additional risk. Logging, mining and new roads have been proposed for several mainland areas including a new road connecting Wrangell with British Columbia along the Bradfield River corridor and new mines in the adjacent Stikine River basin of British Columbia. As logging and development expands on the mainland coast, the appropriateness of habitat management for brown bears needs additional evaluation. An increased understanding of seasonal habitat selection will provide better insight into important bear foraging areas and cover requirements on the mainland coast.

Previous research on the ABC islands has shown those estuary and beach fringes are important brown bear habitats in the late spring and early summer (Schoen and Beier 1990, Titus et al. 2000). Thus, most hunting for brown bears occurs in these habitats. In order to access vulnerability to hunting, we need to know the proportion of the bear population by age and gender using these habitats during the hunting season. If brown bear densities on the mainland coast are substantially lower than expected, greater restrictions on the number of guide/outfitter and big-game hunting permits may be needed, especially if the bears are highly vulnerable. In contrast, larger numbers of bears may allow a greater take. If the bears have a low vulnerability, greater hunting opportunities may be appropriate.

During the TLMP Revision, expert panels expressed concern with the long-term population viability of brown bears unless adequate riparian vegetation was maintained, especially in areas with spawning salmon (*Oncorhynchus* spp.) (Swanston et al. 1996, U.S. Forest Service 1997).

We hypothesized that salmon-spawning areas would also be important foraging areas on the mainland coast during the late summer – early autumn seasons. Limited availability of area may result in greater conflict on the streams among the bears.

STUDY AREA

Southeast Alaska consists of rugged mountains, numerous islands, and conifer-dominated rain forest. Mountains rise from the sea to over 1,400 m. The maritime climate is cool and moist throughout the year. In the Juneau area, the annual precipitation ranges from 135 cm at the airport to 236 cm at downtown. Heavy snow accumulations often occur during winter; higher elevations are snow-covered for 7 to 9 months of the year. The natural vegetation is dominated by temperate rain forest, one of the world's most limited ecosystems (Alaback 1988), interspersed with muskegs and alpine tundra. Because of the lack of frequent, large-scale, catastrophic natural disturbance, the rain forests of southeast Alaska are predominantly in an old-growth condition (Alaback and Juday 1989). Sitka spruce (*Picea sitchensis*) or western hemlock (*Tsuga heterophylla*) dominate the overstory of most plant associations on productive sites (Martin 1988, Alaback and Juday 1989, Samson et al. 1989). Poorly drained sites often contain mountain hemlock (*Tsuga mertensiana*), Alaska-yellow cedar (*Chamaecyparis nootkatensis*), or western red cedar (*Thuja plicata*). The understory, depending on site conditions, may be dominated by shrubs such as blueberry (*Vaccinium* sp.), rusty menziesia (*Menziesia ferruginea*), or devil's club (*Oplopanax horridum*); bunchberry (*Cornus canadensis*), trailing raspberry (*Rubus pedatus*), and skunk cabbage (*Lysichitum americanum*) are common forbs.

A portion of the southern mainland coast of Southeast Alaska, including drainages into the north side of Bradfield Canal and the Unuk River (Fig. 1) was selected for this study. Many of the streams support spawning Pacific salmon (*Oncorhynchus* spp.), including chinook (*O. tshawytscha),* chum (*O. keta)*, coho (*O. kisutch*), pink (*O. gorbuscha*), and sockeye (*O. nerka*). Although all species of Pacific salmon are present, distribution and timing of runs varies greatly. Peak spawning season for most species is during late July through August. Salmon first appear in the streams during early July with peak spawning for most species usually occurring during late July through August. By the end of September, most salmon have finished spawning and few carcasses remain in the streams. Coho salmon continue to spawn through the fall.

Bradfield Canal

This study area includes the drainages flowing into the north shore of Bradfield Canal, from Blake Channel to the Bradfield River; an area located about 50 km southeast of Wrangell, Alaska (Fig. 1). Specifically, we sampled portions of the following streams: Aaron, Oerns, Marten, Old Frank's, and Tom creeks along with the Harding and Bradfield rivers. Each of these streams has reaches with spawning Pacific salmon. The area is mostly roadless and access was primarily by helicopter.

Unuk River

The Unuk River is a transboundary mainland river system, located about 100 km northeast of Ketchikan (Fig. 1). Our study area comprised the 25 km section between the Canadian border and salt water (Fig. 1). In addition, this watershed extends about 50 km into Canada. Although much of the main river channel is too deep and glacial for bears to fish, the watershed contains several clear tributaries with spawning salmon. Most of the Unuk study area is part of Misty

Fiords National Monument and classified as federal wilderness. Housing and other support facilities were available on private land near the mouth of the river. Primary access was by riverboat.

METHODS

Brown Bear Capture

Brown bears were primarily captured during late summer using foot snares set on trails along salmon-spawning streams to deploy GPS radiocollars. On 2 occasions, we attempted to dart bears using a helicopter in the alpine. We saw few bears during these attempts and decided this approach was not cost-effective. For all captures, the bears were approached within darting range and injected with Telazol® (Fort Dodge Animal Health, Fort Dodge, Iowa, USA) for immobilization at a dosage of 7-10 mg/kg estimated body weight (Taylor et al. 1989). In addition to attaching collars and ear tags, we collected blood, tissue, and hair samples for additional analyses (Titus et al. 1999). Tissue samples were sent to Wildlife Genetics International (Nelson, BC, Canada) for individual genotyping (Paetkau 2003).

Location Data

We deployed GPS-equipped (3rd generation, store-on-board) radiocollars (Models TGW-3600 and TGW-3700 - GPS/SOB/D, Telonics, Mesa, AZ) on all captured brown bears except cubs. Each collar was also equipped with a standard VHF transmitter, so the collar could be located in the field. Because our application of the technology was still relatively new, we tried several data acquisition schedules during the study. We continued to assess equipment performance including collar design, battery life, and successful fix acquisition rate. We extended battery life by reducing the fix acquisition rate during the denning period. While in a den, the GPS satellites are usually not available to the collar to obtain a location. Thus, we programmed most collars to collect a GPS location every 30 minutes from 15 April until 15 November, which we considered the active period, and then 1 location per day for the rest of the time (denning period). With this schedule, we anticipated the collars collecting data for about 1 year from deployment. In order to retrieve the location data, we connected the collars with a timed, self-release mechanism. We programmed the collars to self-release on 1 September of the appropriate year. We assumed that the bears would be at low elevation near salmon-spawning areas at that time facilitating the retrieval of the collars. Unfortunately, the bears dropped some collars at other times, sometimes after emerging from the den. In these cases, the collars were often dropped at high elevation in rough topography and a helicopter was needed to retrieve them.

Periodically, we located radiocollared bears with a fixed-winged aircraft. These locations were entered into a GIS database. Often, aerial locations were obtained shortly after the collars were set to release to determine whether the collars had released as scheduled, and if so, their location. If we were unable to retrieve a bear's collar, these observations were our only locations. After we determined that a collar was no longer on a bear, we tracked the collar from the ground until found. If the collar was in a difficult place at high elevation of rough terrain, we used a helicopter to get close and then tracked it from the ground.

After collars were retrieved from the field, we downloaded the location data as a text file using software supplied by Telonics. Next, we imported the data file into Microsoft Access for formatting and database management. A visual basic script, obtained from the Internet (http://www.vbrad.com), was used in Microsoft Access to convert UTC time to local time (Alaska Daylight Time). We used geographic information system (GIS) software (ArcGIS 9.2, ESRI, Redlands, CA) to convert the Microsoft Access data files to geographically-referenced geodatabases and then projected the geographic coordinates (WGS84) to Alaska state plane (NAD 27, zone 1) to match our map databases. We used the activity and temperature sensors in the collar to determine the actual drop date and time. After the activity sensor reading became and remained 0 and the temperature recorded by the collar dropped to ambient air temperature, we assumed that the collar had dropped after the previous location fix. Likewise, we determined the time of death of mortalities using the same approach.

Because the same lab that genotyped our samples also analyzed samples from 2 studies across the border in Canada, we were able to compare our bear identifications with theirs. This information gave us added insight into the extent of movements of brown bears across the international border. We noted the locations of brown bears that had been identified in Canada by genetic studies done in 2004 -2005 in the Stikine River drainage (G. Mowat, personal communication) and the upper Unuk River in 2006 (S. Freeman, personal communication).

Analyses

Fix acquisition rate.—We computed a successful fix acquisition rate for each collar by dividing the number of successful GPS fixes by the total number of attempted fixes during the period of collar deployment, excluding the time thought to be in a den. We did include the time after an "antenna fault" message was recorded by the collar. Sometimes a collar worked intermittently after an antenna fault problem was detected. Thus, the successful fix acquisition rate reflected the performance of a collar while on an animal.

Home range and movements.—The spatial distributions of locations were displayed using GIS software. We defined the seasons as follows: 1) spring = 1 April – 15 May; 2) early summer = 16 May – 15 July; 3) late summer = 16 July – 15 September; 4) autumn = 16 September – 15 November, and winter = 16 November – 31 March. The bears were usually denned during the winter season. Most of the salmon spawning occurred during the late summer. We calculated home ranges (100% convex polygon) using the ArcGIS extension Hawthorne's Analysis Tools. Also, we calculated the maximum distance among locations of each animal and the maximum distance bears were located from nearest salmon-spawning stream.

Hunting vulnerability.—We defined a brown bear as vulnerably to legal beach hunting if it was located within 500 m of the coast during the hunting season. Thus, we buffered the coastline by 500 m and overlaid all of the bear location during the spring (15Mar – 31 May) or autumn (15 Sep – 31 May) hunting seasons. All bears with locations within the 500-m buffer were identified. Also, we looked at which bears were located adjacent to a navigable river during the legal hunting seasons. Only the Unuk River was considered navigable.

Den locations and denning period.—During the late autumn - winter period, we concluded that a bear was in its winter den when the GPS locations became focused on a single place (usually not differing more than 30 m) or successful fixes stopped, and the activity level measured by the collars became near 0. Because we maintained the frequent fix acquisition rate until 15 Nov and began again by 15 April, we could usually determine the location of den site. Often the last location in the autumn was near the first location in the spring, i.e. at the den site. Sometimes we recorded bears at different locations and activity after thought to be at a den. In these cases, we assumed that the bear moved among sites. We retrieved one collar at a den site and described it. We made no attempts to visit other den sites because they were located in remote, inaccessible areas.

RESULTS

Brown Bear Captures

During 2004 to 2008, we captured 41 brown bears (16 males, 25 females) during late summer to deploy GPS radiocollars (Table 1). All bears except 2 were captured using foot snares set on trails along salmon-spawning streams. Two bears were darted from helicopter in the alpine. In the Bradfield Canal study area, we set and checked foot-snares using a helicopter because of difficult access. Because this method was very expensive, we sampled only a few sites in 2004 – 2006 during a relatively short time frame. Altogether, we captured 13 individual brown bears (5 males, 8 females) and attached GPS collars to all of these bears. We recaptured 3 bears (2 males, 1 female) and replaced the collars. In the Unuk River study area, we used a river boat to access most of the drainage within the USA during 2004 – 2008, including the upper reaches near Cripple Creek. Altogether, we captured 28 individual bears (11 males, 17 females) on the Unuk River and deployed GPS collars on 22 bears (9 males, 13 females). We recaptured 1 female bear and replaced the collar (#607). During 16–19 August 2006, we captured 6 female brown bears in the upper Unuk River drainage near Cripple Creek (Table 1). We were surprised that no male brown bears were captured there. Because we had data on fewer male bears than desired, we spent additional time in 2007 and 2008 attempting to collar more males. These efforts resulted in only 3 additional captures of males.

We captured 21 black bears (18 males, 3 females) incidentally to the brown bears, 14 of these black bears (12 males, 2 females) were captured in the Unuk River drainage and 7 (6 males, 1 female) in the Bradfield Canal study area. The black bears were eartagged and released.

GPS Location Data

We retrieved 15 of the 16 GPS collars deployed in the Bradfield study area (Table 1). Brown bears #501, #508, and #509 were recaptured and their collars replaced. Apparently, the collar on bear #506 did not release successfully and remained on the bear. On the Unuk River, we were able to retrieve only 16 of the 21 collars deployed. Collars not retrieved included 3 collars deployed in 2004 that dropped off the bears in remote areas. We searched for these collars in 2006, but we were unable to detect the VHF signal. One collar (#609) dropped in Canada about 26 km northeast of the international border. We searched for this collar in May 2006, but did not detect the VHF signal. The other 2 collars dropped within Misty Fiords National Monument; 1 collar (#602) in the adjacent upper Leduc River and 1 collar (#608) on an upper slope above Cripple Creek. Because these 2 collars dropped within Misty Fjords National Monument Wilderness, we were unable to pursue retrieving them with use of a helicopter until a permit was received from the U.S. Forest Service in October 2006. By then, the VHF transmitters had failed on several of the collars. Apparently, the collar on brown bear #616 didn't release correctly and was still on the bear during autumn 2006. In May 2007, this male bear was taken by a hunter and still carrying the collar. Unfortunately, we were unable to pick-up the VHF signal from male brown bear #615. We received a report of a collared brown bear observed on the Iskut River in

Canada during August 2006. Bear #615 was hair-snared on the Iskut River in 2004 (G. Mowat, personal communication) and may have moved out of our search area.

The number of successful fixes collected by a collar varied greatly due to length of deployment, fix acquisition schedules, and proportion of successful fixes. For 31 collars, the number of successful fixes for a collar ranged from 74 to 8,779 (median = 5,190) (Table 1). The successful fix rate ranged from 3 to 89% (median = 66). Collars with a poor fix rate often developed antenna problems. Later in the study, we switched to a urethane outer belting which helped protect the GPS antenna.

Movements and Home Range

We obtained adequate locations from 20 brown bears (4 males, 16 females) to document movement patterns. For 4 males with an adequate number of locations, annual home range sizes ranged from 174 to 1,480 km^2 (median = 211 km^2) (Table 2, Fig. 2). Unfortunately, we collected data from fewer male brown bears than planned. Male bears appeared more difficult to capture, their released collars more difficult to retrieve (4 collars were not retrieved), and one collar had a severely damaged antenna, probably due to fighting. One collar (#609) dropped in Canada near Sulphurets Creek and another (#602) on the Leduc River about 21 km south of his capture site on the Unuk River. By the time we returned to pick up these collars, the VHF transmitters no longer worked. For 2 other males (#615 and #626), their VHF radios were never located again. Movements of collared males varied greatly. For example, male brown bear #505 traveled extensively from his capture site near Marten Lake in the Bradfield Canal including trips to Wrangell Island and the Stikine River near Wrangell. For several other males with few relocations, the maximum distance among points suggested that they had large home ranges, but we didn't collect adequate information on these bears for an accurate assessment. For example, adult male #609 was relocated once near Sulphurets Creek in the upper Unuk, about 62 km from his capture site near the mouth of the Unuk.

We retrieved all but 2 collars deployed on female brown bears. One collar (#506) did not release properly and another (#608) collar dropped in rough terrain within the restricted wilderness. Female home range size was quite variable (Table 2, Fig.3). For 16 female bears, home range sizes ranged from 23 to 627 km^2 (medium = 146 km^2). Although the maximum size of a male's home range was more than twice the largest female's (1,480 vs. 627 km^2), the median home size of male home ranges was not statistically significantly larger (Mann-Whitney Test, $U = 17.5$, $P = 0.14$). Small sample size for males made comparisons difficult.

The greatest distance among locations for male bears ranged from 48 to 64 km (median = 57 km). For females, the maximum distance was smaller (Mann-Whitney Test, $U = 1.5$, $P < 0.001$), ranging from 13 to 48 km (median = 27 km). Also, male bears ventured farther from salmon spawning streams (mean = 22 km) than females (mean = 10.6 km) (t-test, $t_{19} = 1.985$, $P = 0.042$). Thus, male brown bears appeared to travel more extensively than females, but our small sample of males made comparisons difficult.

In regards to hunting vulnerability, we located 7 of the 8 Bradfield brown bears that were tracked during the spring and fall hunting seasons within 500 m of the coast. Five of the 7 bears were near the beach during the spring hunting season and all were near the beach during the fall season. In the Unuk River, 7 of the 13 bears tracked during the hunting season were located within 500 m of the beach. Four of the animals were near the beach during the spring hunting season and 5 bears were near the beach during the fall. Two bears were vulnerable during both the spring and fall seasons. All of the animals would have been accessible by river boat during both the spring and fall hunting seasons. Thus, a high proportion of the brown bears in both study areas were highly vulnerable to hunting during either the spring or fall seasons.

From the GPS location data, we were able to investigate the amount of transboundary movement of brown bears between coastal Alaska and adjacent areas in British Columbia, Canada. Although no bears captured in the Bradfield were located in Canada, adult female bear #512 was located within 1 km of the border in the upper Bradfield River area and male brown bear #505 traveled to within 5 km of the Canadian border along the Stikine River. In the Unuk River drainage, we found 6 collared bears crossing into Canada. Females #607 and #613 traveled 18 km and 5.8 km into Canada, crossing the border along a mountain ridge on the south side of the drainage. Females #619 and #620 travelled up the main river bottom to the border, but did not cross. Males #601 and #616 were located about 21 km upstream of the border near the junction of the South Unuk River. Additionally, we located male brown bear #609 near Sulphurets Creek, 27 km upstream of the international border.

To further explore transboundary movements, we compared DNA results collected from another part of this stud with those from brown bears hair-snagged in the Upper Stikine and Iskut rivers (Garth Mowat, personal communication) and the upper Unuk River (S. Freeman, personal communication) in Canada to look for genetic matches of individuals. For the Stikine – Iskut river sample, this analysis found 3 individual bears both samples. A young male brown bear (#615) that we captured at Gene's Creek on the Unuk River in August 2005 had been previously hair snagged in 2004 in Canada along the Iskut River near Bronson Creek, about 62 km from his capture site. Another young male brown bear that had been identified in a hair snag along the Iskut River in summer 2004 was shot by a hunter at the mouth of Tom's Creek in the Bradfield Canal in spring 2006, a straight-line distance of about 65 km. Finally, we collected hair from a female bear in 2006 along the Harding River that had also been hair snagged along the Craig River, a tributary of the Iskut River, in 2004, a distance of about 52 km. In the upper Unuk River sample, we had 2 brown bears in common. Radiocollared female #607 was hair snagged about 3 km across the border in upper Gracy Creek. She had used this area in 2004 to 2007 while collared. A male that we had hair snared (#5574) on 08/09/2007 at Hooligan Creek on lower Unuk River was hair snagged in 2009 near Storie Creek in the upper Unuk River, about 31.5 km upstream of the border.

From the GPS locations, we were able to determine the location of winter dens (Fig. 2) and the denning period (Table 3). We visited only one actual den site (#509). Brown bears began entering dens on October 10 and the last bear entered on January 17. We found the median entrance date was October 31. Brown bears began exiting dens on April 12 with the last bear exiting on May 17. The median exit date was May 3. The elevation of den locations ranged from 110 to 1,300 m with a median of 610 m. A couple of bears appeared to use multiple den sites during a winter and at least 4 bears left their original den site for a period of time, possibly returning to the same den.

After emerging from dens (Fig. 4), some of the brown bears lingered in the higher elevations. Other bears moved quickly to the river bottoms and estuaries. Thus in the early spring and early summer (Fig. 5) bears remained more widely distributed. By late summer, nearly all bears had moved to the river bottoms and then spent much of their time near salmon-spawning streams and estuaries (Fig. 6). This distribution continued through the early autumn (Fig. 7) until denning time.

In the Unuk, the males appeared to travel the length of the main river, spending time in the estuary and along the river bottom. In contrast, only 5 of 12 (42%) collared females were located in the estuary. Of the 6 female bears captured at Cripple Creek on the upper Unuk River, only 1 travelled to the estuary on the lower river (#623).

DISCUSSION

We found that brown bears on the southern mainland coast had substantially greater movements and spent more time at lower elevations than brown bears on the ABC islands. We found that home ranges of brown bears on the mainland coast were much larger in size than on the ABC islands, roughly 2.3 times for males and 4.7 times for females. One large male bear travelled from the Bradfield Canal area to the Stikine River and back. This bear also swam across Eastern Passage to Wrangell Island. These larger movements make the bears more vulnerable to exploitation and disturbance.

Substantial transboundary movements of brown bears indicate that management needs to consider multiple jurisdictions. Brown bear population management needs to consider activities on both sides of the international border. In the Unuk River drainage, we found substantial movement of bears across the border, especially as far as the South Unuk River. Bears travelled along the main Unuk River and also along the ridge top. In the Bradfield, we recorded less movement between Canada. We didn’t record any bears travelling to Canada, but we did detect 2 bears in the Bradfield that had previously been tagged near the Iskut River in Canada.

Because most of the brown bears use estuary and beach fringe habitats during the spring and fall hunting seasons, these bears are highly vulnerable to hunting, especially the males. Although home range areas are large, the bears still seek out the estuaries and beach areas during the late spring and fall. These areas are also used extensively by bear hunters, especially in the spring.

We found that GPS technology worked well to record movements of free-ranging brown bears. With a few modifications of the collars, we were able to get a successful fix rate near 75%. Our configuration of battery capacity and duty cycle yielded nearly 10,000 fix attempts over a year. Because of the remote terrain, we did have difficulties retrieving collars after release. By increasing the battery life of the VHF transmitter, we allowed ourselves more options to retrieve the collars.

We found that foot-snaring was the only productive method to capture brown bears. The bears spend little time in the alpine, so capture using a helicopter wasn’t a viable option most of the time. Likewise, the bears were not often vulnerable in the estuaries either. Fluctuating water conditions and salmon runs on the Unuk River made foot-snaring difficult at times. We found males difficult to capture, so males were under represented in the study. Other evidence collected during this study suggested that the sex ratio may be biased towards females. We were disappointed not to have collared additional male bears because we obtained little data on male bears. Male bears traveled more extensively than originally expected and dropped their collars in remote areas of Misty Fjords National Monument which are classified as federal wilderness, causing problems in retrieving the collars.

MANAGEMENT IMPLICATIONS

Brown bear management on the mainland coast needs to consider greater movements of individual bears, both males and females. These larger movements make them more vulnerable to exploitation and disturbance. Substantial transboundary movements of brown bears indicate that management needs to consider multiple jurisdictions. Brown bear population management needs to consider activities on both sides of the international border. Because most of the brown bears used estuary and beach fringe habitats during the spring and fall hunting seasons, these bears are highly vulnerable to hunting, especially the males. Although home range areas are large, the bears still seek out the estuaries and beach areas during the late spring and fall. These areas are also used extensively by bear hunters, especially in the spring.

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FIGURES

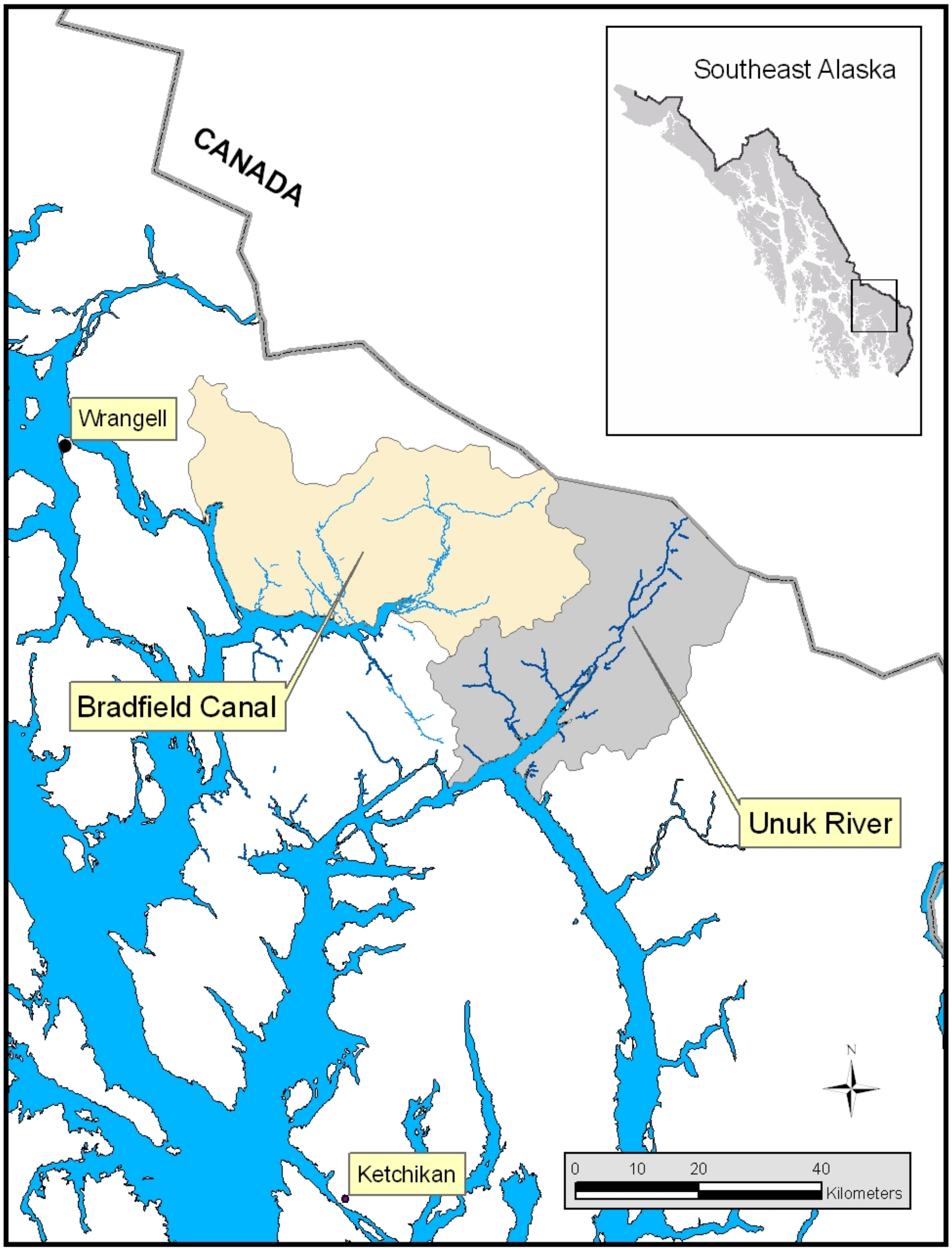

Figure 1. Location of brown bear study areas on the southern mainland coast of Southeast Alaska.

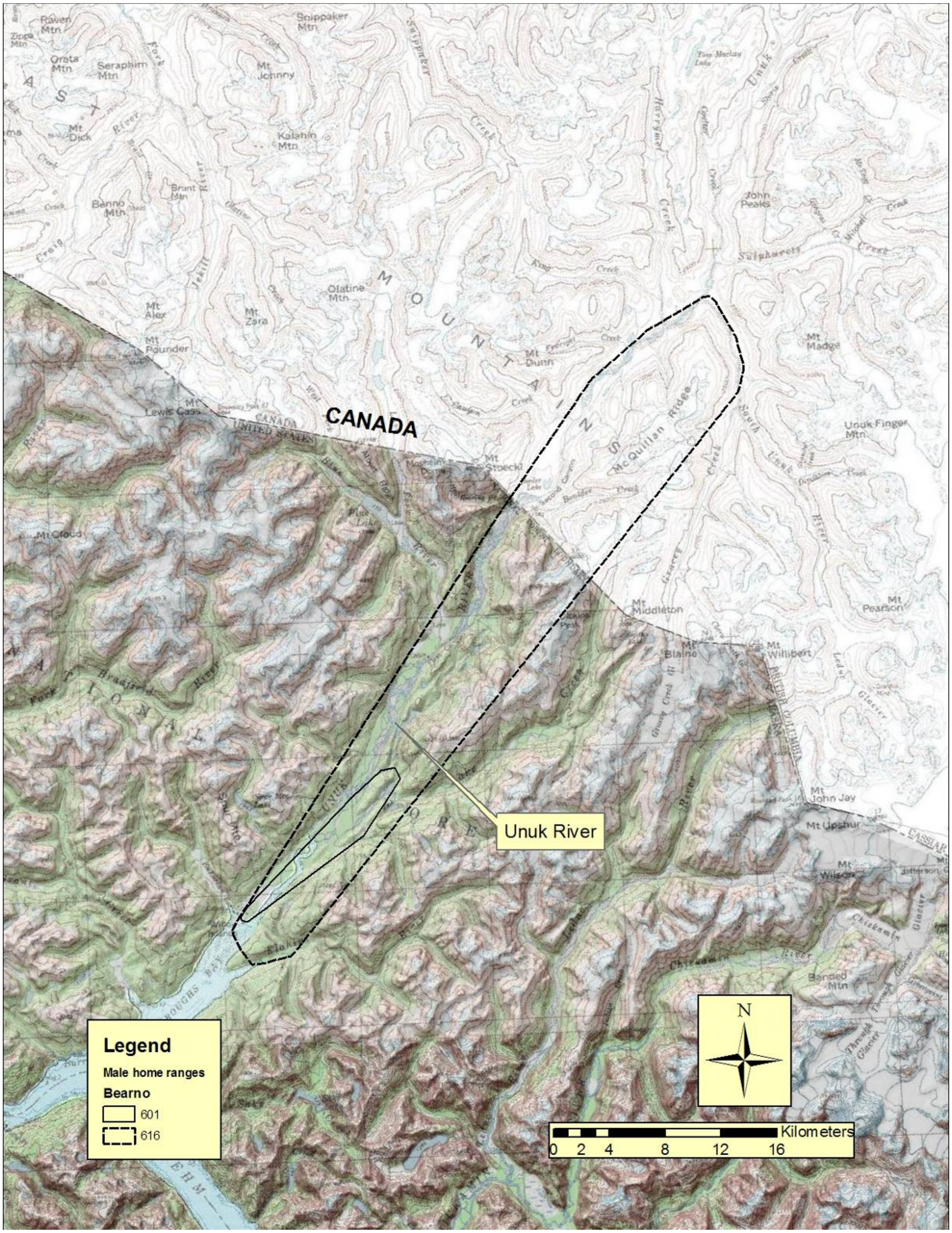

Figure 2. Home range areas of 2 male brown bears collared in Unuk River study area, Southeast Alaska during 2004 - 2008.

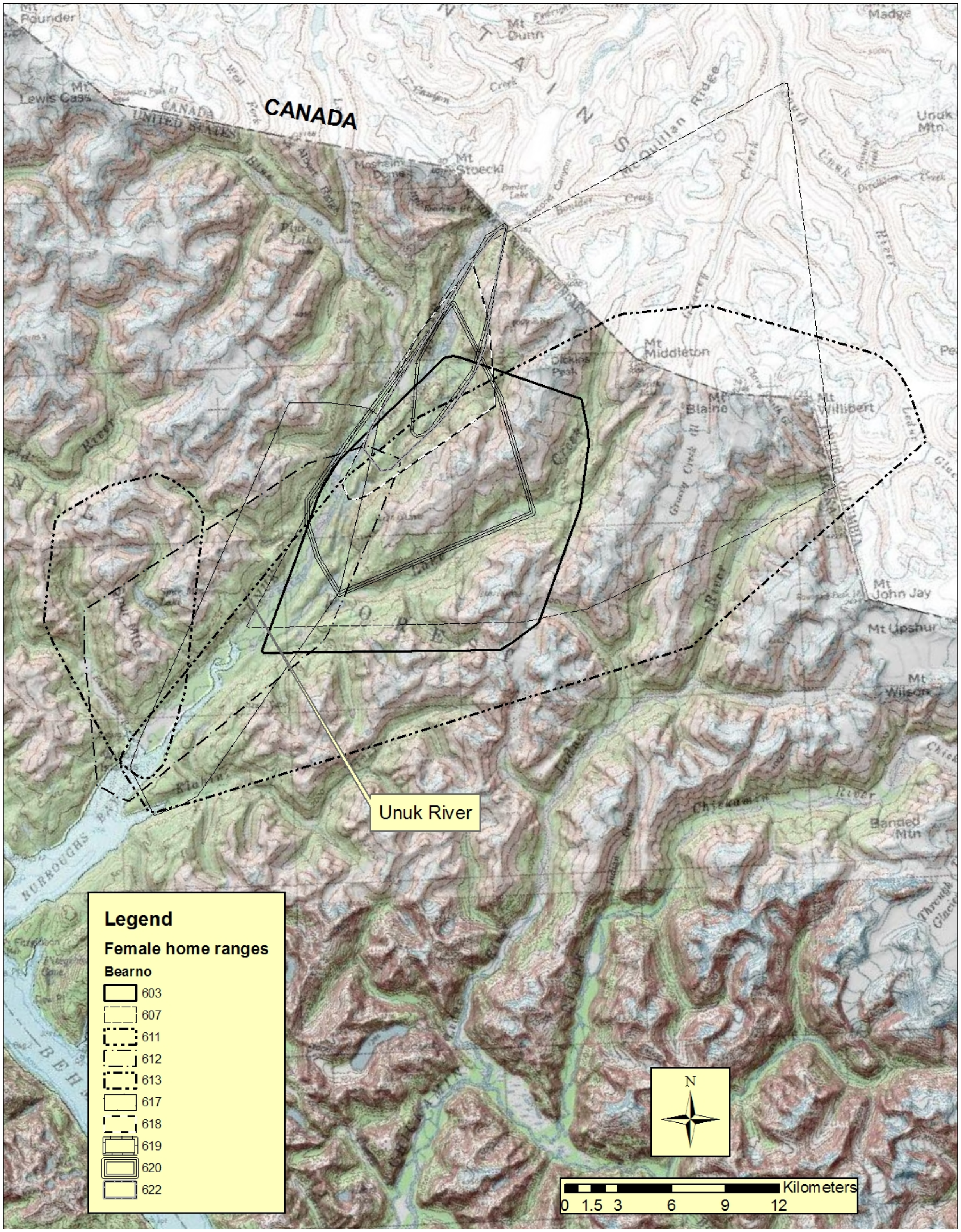

Figure 3. Home range areas of 10 female brown bears collared in Unuk River study area, Southeast Alaska during 2004 – 2008. Female home range areas overlapped greatly.

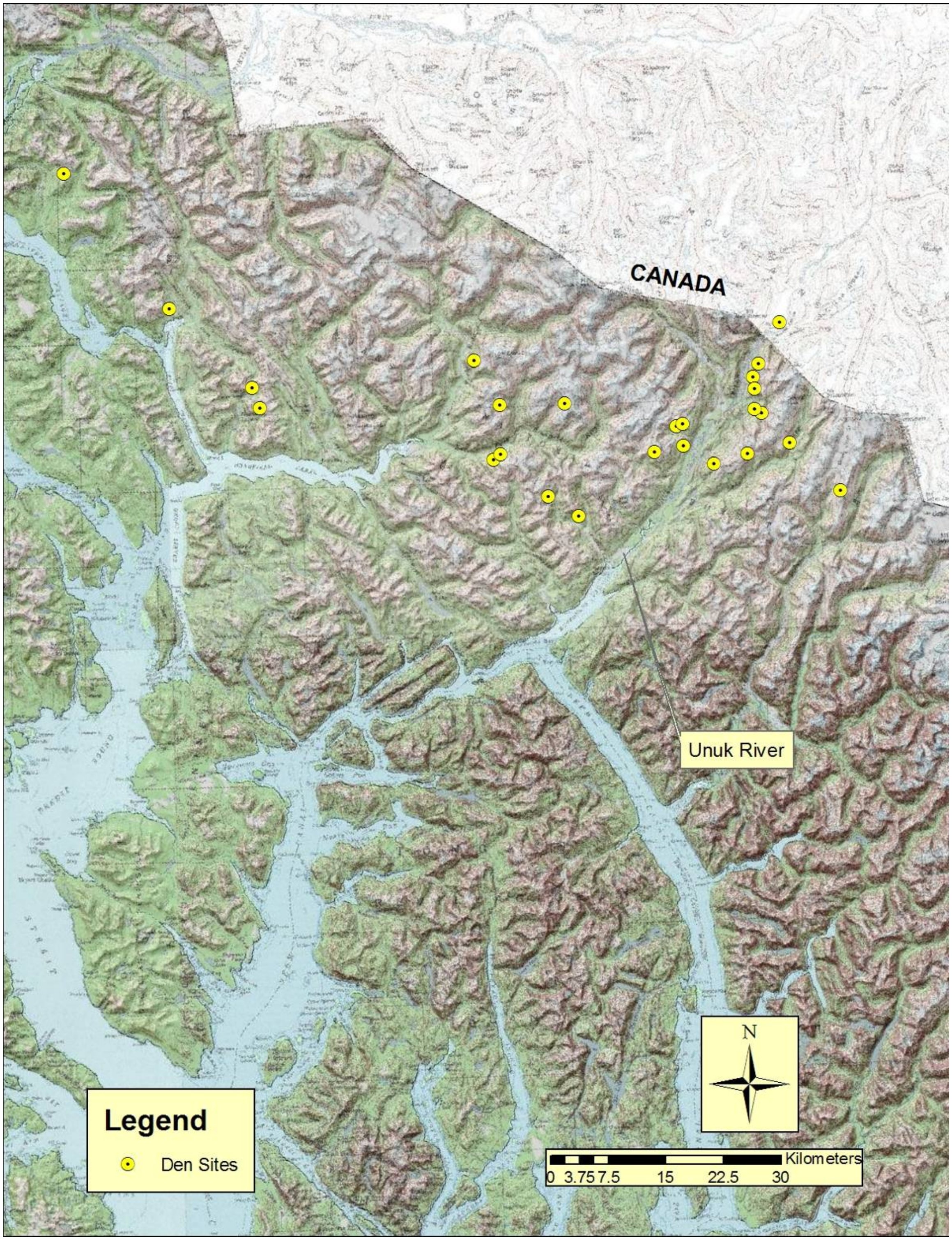

Figure 4. Brown bear den site locations in the Bradfield - Unuk study area, Southeast Alaska during 2004 – 2008.

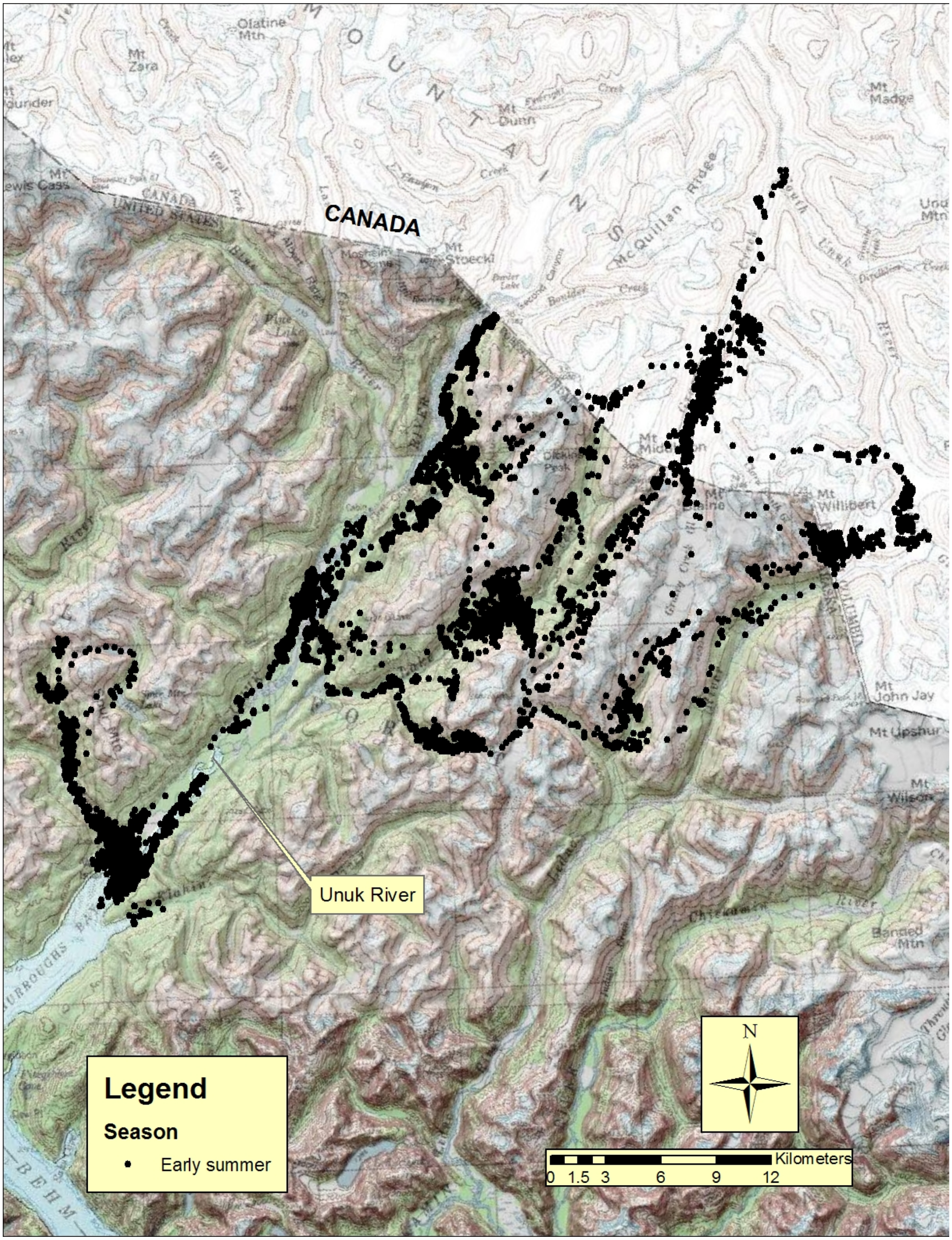

Figure 5. All brown bear locations during the early summer season in the Unuk River, Southeast Alaska during 2004 – 2008.

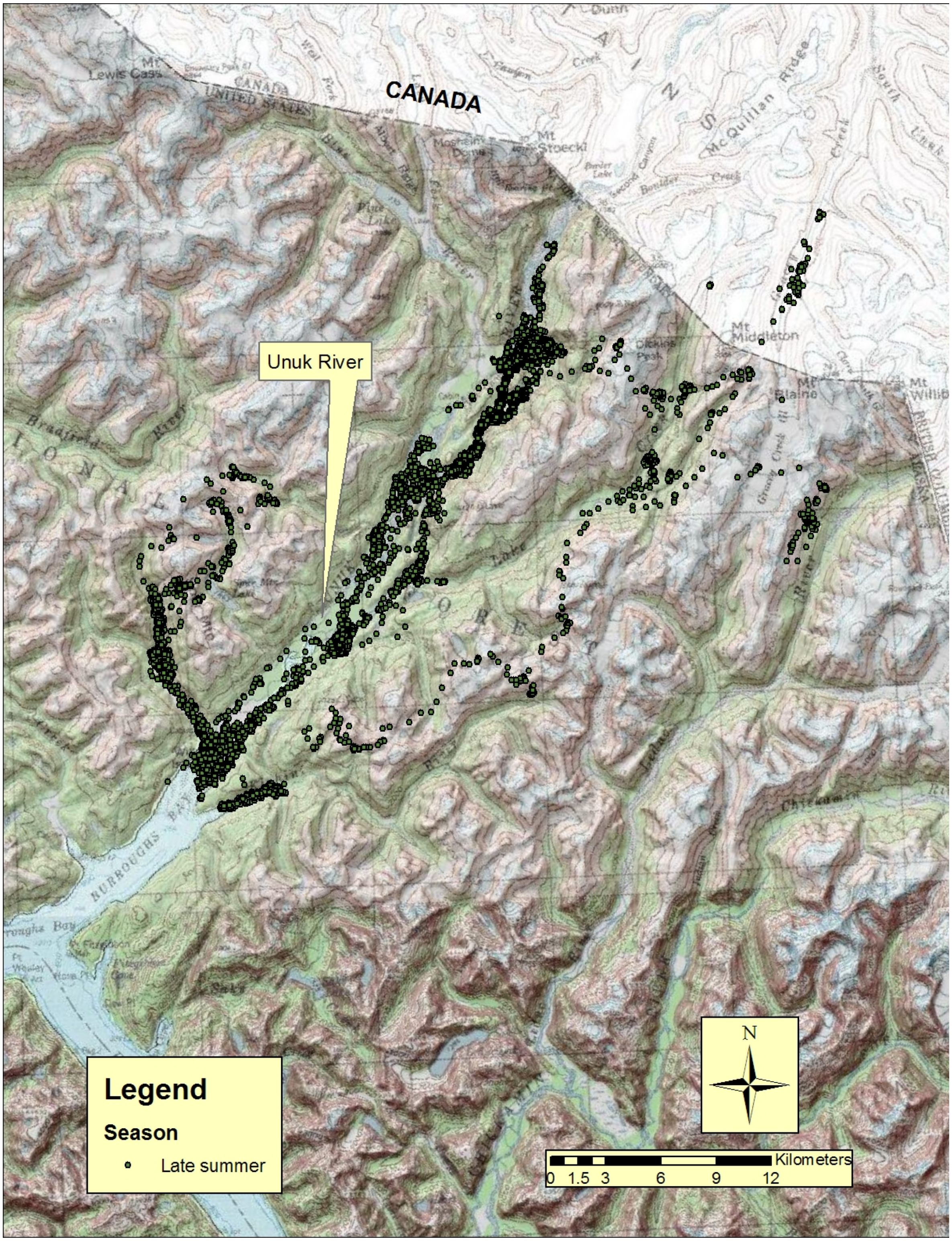

Figure 6. All brown bear locations during the late summer season in the Unuk River, Southeast Alaska during 2004 – 2008. Most of the locations were in the river bottoms.

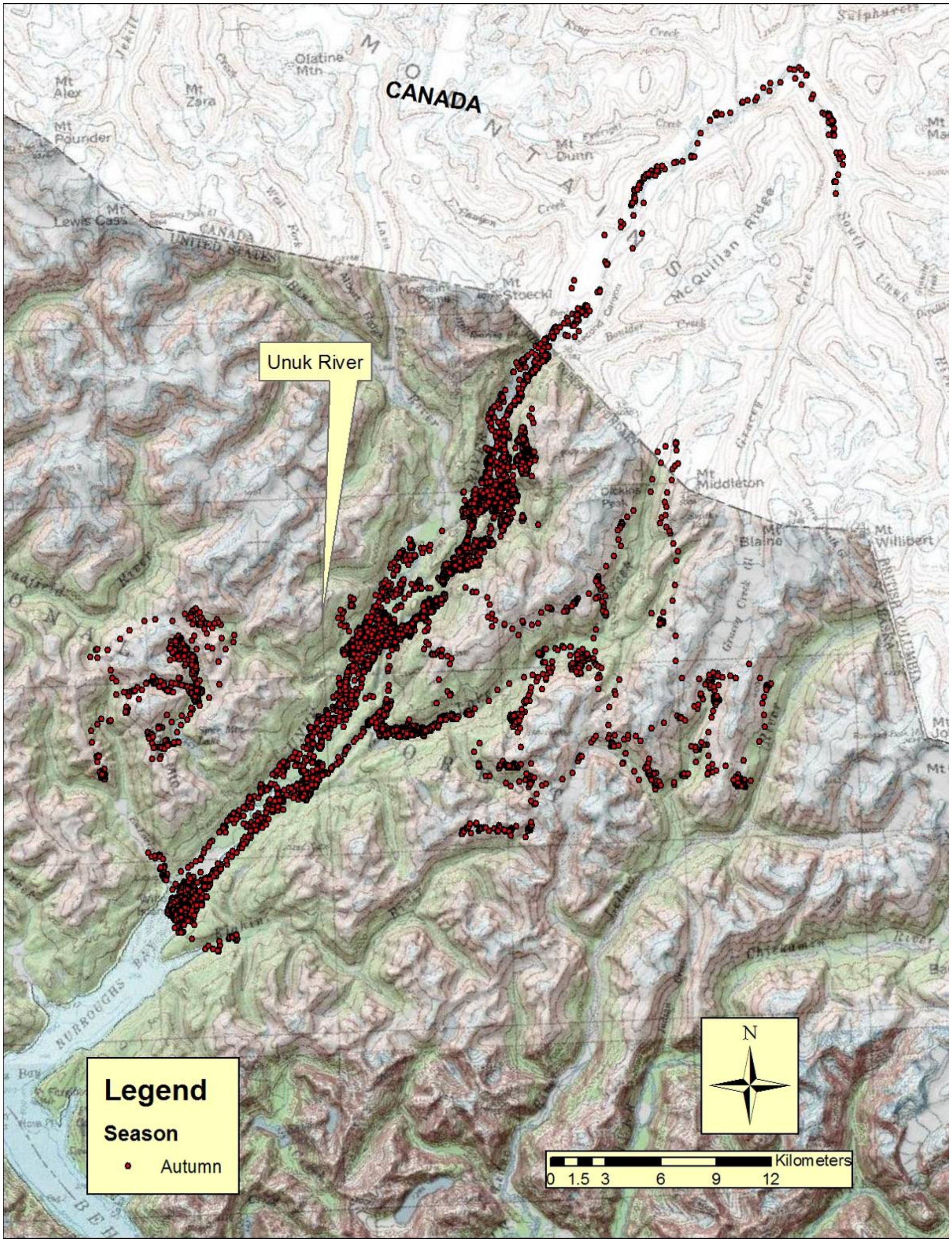

Figure 7. All brown bear locations during the autumn season in the Unuk River, Southeast Alaska during 2004 – 2008.

TABLES

Table 1. Sex, age, and GPS fix data for brown bears captured on the southern mainland coast of Southeast Alaska during 2004 – 2008. A fix was defined as an attempt by the GPS receiver to obtain a location. Fix attempts during the winter denning period were excluded.

GPS collar CTN	Bear number	Sex	Age	Capture date	End data collection	Fix attempts			Comments
						Total	Successful	%	
498323	501	F	12	07/24/2004	12/28/2004	11,155	1,232	11.0	Recaptured
498321	501	F	13	06/24/2005	07/15/2006	10,015	1,425	14.2	Released, antenna fault problem
498322	502	F	7	07/25/2004	09/04/2004	2,958	2,026	68.0	Released
518520	503	F	2	08/09/2004	09/04/2004	1,893	1,335	70.5	Released
498325	504	M	6	08/14/2004	09/04/2004	1,530	1,530	77.0	Released
518519	505	M	23	06/23/2005	09/01/2006	11,793	5,851	49.6	Released
496049	506	F	6	06/24/2005	No data				Failed to release
496048	507	F	2	08/15/2005	09/01/2006	7,682	5,627	73.9	Released
496050	508	M	5	08/16/2005	09/01/2006	9,003	6,866	76.3	Released
582632	508	M	6	08/10/2006	09/01/2007	9,663	3,736	38.7	Released, antenna fault problems
498327	509	M	3	08/16/2005	06/13/2006	4,636	2,219	47.9	Collar dropped near den
582641	509	M	4	08/08/2006	07/09/2007	6,641	3,807	57.3	Found dead 7/09/2007
496047	510	F	10	08/17/2005	10/31/2005	4,202	105	02.5	Released, antenna fault problems
582634	511	F	14	07/29/2006	09/01/2007	9,697	7,136	73.6	Released
582634	512	F	16	08/08/2006	09/01/2007	8,309	7,013	84.4	Released
585752	513	M	2	08/30/2006	09/01/2007	8,734	6,440	73.7	Released
498329	601	M	7	08/24/2004	09/07/2004	684	477	70.2	Killed by hunter; antenna damaged
496051	602	M	9	08/24/2004	No data				Unable to retrieve
496046	603	F	9	08/25/2004	09/01/2005	10,012	6,948	69.4	Released
	604	F	0	08/25/2004	No data				No collar
	604	F	4	08/14/2008	No data				No collar
	605	M	0	08/25/2004	No data				No collar

Table 1. Continued.

GPS collar CTN	Bear number	Sex	Age	Capture date	End data collection	Fix attempts			Fate of collar
						Total	Successful	%	
	606	M	1	08/26/2004	No data				No collar
496043	607	F	4	08/28/2004	09/01/2005	9,886	8,779	88.8	Released
582638	607	F	6	08/18/2006	08/23/2007	8,685	2,414	27.8	Released; antenna problem
498326	608	F	15	09/01/2004	No data				Unable to retrieve
496053	609	M	11	09/02/2004	No data				Unable to retrieve
	610	M	2	09/02/2004	No data				No collar
496052	611	F	10	09/03/2004	09/01/2005	9,038	5,936	65.7	Retrieved
496045	612	F	4	08/28/2005	09/01/2006	8,594	5,864	68.2	Retrieved
496044	613	F	15	08/28/2005	08/31/2006	8,469	5,600	66.1	Retrieved
	614	F	1	08/28/2005	No data				No collar
568315	615	M	4	08/30/2005	No data				Unable to retrieve
498322	616	M	7	08/31/2005	04/25/2006	3,467	2,337	67.4	Retrieved; hunter kill
498323	617	F	6	09/01/2005	06/24/2006	5,900	5,192	88.0	Retrieved; mortality
582644	618	F	8	08/16/2006	09/01/2007	9,514	6,101	64.1	Retrieved
518843	619	F	21	08/17/2006	09/01/2007	9,146	5,282	57.8	Retrieved
582633	620	F	17	08/17/2006	09/01/2007	8,771	5,190	59.2	Retrieved
	621	F	2	08/17/2006	No data				No collar
586350	622	F	18	08/18/2006	09/01/2007	8,737	6,146	70.3	Retrieved
582643	623	F	20	08/19/2006	05/21/2007	3,889	1,929	49.6	Retrieved
600785	626	M	10	09/01/2007	No data				Unable to retrieve
600781	627	M	9	08/14/2008	09/17/2008	813	402	49.4	Unable to retrieve; remote download
	628	F	4	08/24/2008	No data				No collar
	629	F	3	08/26/2008	No data				No collar
617964	630	M	6	08/27/2008	09/02/2008	159	74	46.5	Retrieved; natural mortality

Table 2. Movements and home ranges of brown bears on the south mainland coast of Southeast Alaska during 2004 – 2008.

Bear number	Sex	Period	Home range (100% CP)		Maximum distance among points		Maximum distance from salmon stream		Comments
			km²	mi²	km	mi	km	mi	
Bradfield study area									
501	F	07/24/04 – 12/28/04 06/25/05 – 07/15/06	225	87	48	30	21	13	Recaptured in 2005
505	M	06/23/05 – 09/01/06	1,479	571	64	40	21	13	
507	F	08/29/05 – 09/01/06	267	103	48	30	19	12	
508	M	08/16/05 – 09/01/06 08/10/05– 09/01/07	174	67	55	34	8	5	Recaptured in 2006
509	M	08/16/05 – 06/13/06 08/08/06 – 07/09/07	181	70	48	30	39	24	Recaptured in 2006 Died 07/09/07
510	F	08/17/05 – 10/31/05	2	1	2	1	1	1	Collar failed early
511	F	07/29/06 – 09/01/07	307	119	28	11	16	6	
512	F	08/08/06 – 09/01/07	331	128	34	13	27	10	
513	F	08/30/06 – 09/01/07	128	49	16	6	5	2	

Table 2. Continued.

Bear number	Sex	Period	Home range (100% CP) km^2	Home range (100% CP) mi^2	Maximum distance among points km	Maximum distance among points mi	Maximum distance from salmon stream km	Maximum distance from salmon stream mi	Comments
Unuk River study area									
603	F	08/25/04 – 09/01/05	132	82	23	14	12	7	
607	F	08/28/04 – 09/01/05 08/17/06 – 08/23/07	362	225	43	27	17	11	Recaptured 8/17/06
611	F	08/25/04 – 09/01/05	66	41	17	11	11	7	
612	F	08/28/05 – 09/01/06	174	67	26	16	3	2	
613	F	08/28/05 – 08/31/06	627	242	48	30	26	16	
616	M	08/31/05 – 04/25/06	241	150	59	37	21	13	Shot by hunter
617	F	09/01/05 – 06/24/06	145	56	26	16	3	2	Found dead.
618	F	08/16/06 – 09/01/07	49	19	15	9	1	1	
619	F	08/20/06 – 09/01/07	23	9	13	8	2	1	
620	F	08/17/06 – 09/01/07	111	43	18	11	8	5	
622	F	08/18/06 – 09/01/07	36	14	15	9	3	2	
623	F	08/19/06 – 05/21/07	147	57	28	17	6	4	

Table 3. Period in winter den and elevation of den sites for radiocollared brown bears captured on the south mainland coast of Southeast Alaska during 2004 – 2008.

Bear number	Study area	Sex	Denning period	Elevation (m)	Comments
501	Bradfield	F	12/24/04	950	Battery failed while in den.
501	Bradfield	F	10/19/05 – 05/11/06	230	Antenna failure while in den.
505	Bradfield	M	11/21/05 – 05/09/06	790	Remained in den entire time.
507	Bradfield	F	10/07/05 – 05/17/06	900	Remained in den entire time.
508	Bradfield	M	12/19/05 – 04/22/06	610	Remained in den entire time.
508	Bradfield	M	10/31/06 – 05/05/07	400	Remained in den entire time; den sites 1.2 km apart.
509	Bradfield	M	10/20/05 – 05/08/06	1,130	Remained in den entire time.
509	Bradfield	M	10/30/06 – 05/15/07	1,220	Remained in den entire time; den sites 13.3 km apart.
511	Bradfield	F	11/15/06 – 05/16/07	880	Remained in den entire time.
513	Bradfield	F	10/21/06 – 04/17/07	490	Remained in den entire time.
603	Unuk	F	11/08/04 – 04/20/05	550	Left den at least once during mid March.
607	Unuk	F	11/21/04 – 04/27/05	1,300	Remained in den entire time.
607	Unuk	F	11/12/06 – 05/16/07	850	Remained in den entire time; den sites 4.6 km apart.
611	Unuk	F	10/19/04 – 04/12/05	520	Left den site once in mid March.
612	Unuk	F	10/29/05 – 05/09/06	550	Left den site once in mid March.
613	Unuk	F	10/31/05 – 05/11/06	610	Remained in den entire time.
616	Unuk	M	01/17/05 – 04/15/06	110	Moved 0.3 km to new site on 4/6/06.
617	Unuk	F	12/27/05 – 04/24/06	970	Left den site for several days during March.
618	Unuk	F	11/11/05 – 05/02/06	460	Remained in den entire time.
619	Unuk	F	10/22/06 – 10/29/06	700	Used 2 sites 1.8 km apart;
619	Unuk	F	11/03/06 – 05/03/07	460	2nd site.
620	Unuk	F	10/30/06 – 05/15/07	230	Remained in den entire time.
622	Unuk	F	10/30/06 – 05/14/07	520	Remained in den entire time.
623	Unuk	F	10/19/06 – 05/01/07	1,090	Left den 4 times for short periods after 4/18/07.

Chapter 3

ABUNDANCE OF BROWN BEARS ON THE SOUTHERN MAINLAND COAST OF SOUTHEAST ALASKA

INTRODUCTION

Coastal brown bears (*Ursus arctos*) are a species of special public interest in southeastern Alaska because of their importance to forest dynamics (Hilderbrand et al. 1999a, Helfield and Naiman 2006), forest management (Sidle and Suring 1986, USDA Forest Service 1997), and increasing demands for both consumptive and non-consumptive human uses like hunting or viewing (Miller et al. 1998, Tollefson et al. 2005). Recently, the demand for opportunities to hunt brown bears has increased on the mainland coast of southeast Alaska (Porter 2001, 2003).

Because of concerns with the overharvest of brown bears, a moratorium on the issuance of additional USDA Forest Service (FS) special-use permits for guiding brown bear hunts in Game Management Units 1A and 1B (i.e., southern mainland coast of southeast Alaska) was implemented beginning in Spring 2001 (Porter 2003). Determining the appropriate number of guide/outfitter special-use or big-game hunting permits can only be made with an adequate knowledge of brown bear numbers, movements, availability, and vulnerably.

Little basic biological information is available to guide brown bear management here (Porter 2001). Evidence suggests that brown bear densities may be much lower on the mainland coast compared with Admiralty, Baranof, and Chichagof islands (ABC islands; Porter 2001, Whitman 2003) where brown bear abundance (Miller et al. 1997) and ecology (Schoen and Beier 1990, Titus et al. 1999, Flynn et al. 2007) have been studied extensively. Thus, an understanding of brown bear abundance and ecology on the mainland coast in southeastern Alaska has emerged as a research priority (Flynn, ADF&G, personal communication).

To learn about bear numbers on the southern mainland, we wanted to utilize noninvasive sampling to estimate bear numbers. Noninvasive collection of hair has become a widely used technique to generate estimates of bear population size (Boulanger et al. 2002, Kendall et al. 2008). The most common technique involves using systematically distributed barbed-wire fences strung around a scent lure to collect bear hair (Woods et al. 1999). This technique has been successfully employed in low-density bear populations (Woods et al. 1999, Mowat and Strobeck 2000), but might not be suitable for areas with dense bear populations where bears concentrate during some time of the year (e.g., at coastal streams with spawning Pacific salmon [*Oncorhynchus* sp.]). In areas with dense bear populations or where bears concentrate, a single catch snare has been used to collect hair from individual bears (Beier et al. 2005). Thus, we used a single-catch hair snare to collect bear hair along salmon streams to estimate bear populations in two areas of southeast Alaska.

Our objective was to estimate brown bear population size in 2 areas of the southern mainland coast of Southeast Alaska.

STUDY AREA

Southeastern Alaska consists of rugged mountains, numerous islands, and conifer-dominated rain forest. Elevations range from sea level to over 2,090 m. The maritime climate is cool and moist throughout the year. Annual precipitation ranged from 224 cm at Wrangell, Alaska to 361 cm at Ketchikan, Alaska. Heavy snow accumulations often occur during winter; higher elevations are snow-covered for 7 to 9 months of the year. The natural vegetation is dominated by coastal, temperate rain forest interspersed with muskegs and alpine tundra. Because of the lack of frequent, large-scale, catastrophic natural disturbance, the rainforests of southeastern Alaska are predominantly in an old-growth condition (Alaback and Juday 1989). Sitka spruce (*Picea sitchensis*) or western hemlock (*Tsuga heterophylla*) dominate the overstory of most plant associations on productive sites (Martin 1988, Alaback and Juday 1989), with Alaska-yellow cedar (*Chamaecyparis nootkatensis*), or western red cedar (*Thuja plicata*) in poorly drained sites. The understory, depending on site conditions, may be dominated by shrubs such as blueberry (*Vaccinium* spp.), rusty menziesia (*Menziesia ferruginea*), or devil's club (*Oplopanax horridum*); bunchberry (*Cornus canadensis*), trailing raspberry (*Rubus pedatus*), and skunk cabbage (*Lysichitum americanum*) are common forbs.

Many streams in the area support spawning Pacific salmon, including Chinook (*O. tshawytscha*), chum (*O. keta*), coho (*O. kisutch*), pink (*O. gorbuscha*), and sockeye (*O. nerka*). The distributions and timings of salmon runs vary within the region and by species. Salmon first appear in the streams during early July with peak spawning for most species usually occurring during late July through August. By the end of September, most salmon have finished spawning and few carcasses remain in the streams. Coho salmon continue to spawn through the fall.

We studied brown bears in 2 locations of the mainland coast of southern Southeast Alaska (Fig. 1). The Bradfield Canal study area located about 50 km southeast of Wrangell Alaska, encompassed 1,617 km^2 and included drainages flowing into the north shore of Bradfield Canal, from Blake Channel to the Bradfield River (Fig. 1). Specifically, we sampled portions of Aaron, Oerns, Marten, Old Frank's, and Tom creeks along with the Harding and Bradfield rivers (Fig. 2). Each stream has reaches with spawning Pacific salmon. The Unuk River is a transboundary mainland river system, located about 100 km northeast of Ketchikan (Fig. 1). The study area comprised the 25-km section of river and associated tributaries between the Canadian border and salt water (Fig. 3). Although much of the main river channel was too deep and glacial for bears to fish, the watershed contained several clear tributaries that supported spawning salmon.

METHODS

Sampling Methods

We estimated bear abundance in the Bradfield Canal area during 2005 and 2006 and the Unuk River area during 2007 (Fig. 1) using a DNA-based, capture-mark-recapture (CMR) approach. We identified individual brown bears during capture sessions based on microsatellite genotyping. We collected brown bear hair for genetic analysis using a single-catch hair snare (Beier et al. 2005). We set most hair snares along established bear trails, usually within 25 m of the stream edge. We placed hair snares opportunistically and at variable intervals along the banks of the selected portions of streams. We focused on stream segments with evidence of spawning salmon and with suitable conditions for bears to capture fish. Clear water, low gradient channels, and no barriers to fish passage characterized these stream segments. Often, only small tributaries of larger streams met these criteria. We set snares in late July or early August and checked them 3 times during August (Table 1).

To investigate if some bears were not visiting salmon streams, we placed lure stations away from salmon-spawning areas, but in places where bears might have traveled (e.g., tidal grass flats). At each lure station, we used a commercial crab bait jar filled with cotton balls saturated with a mixture of beaver castor and commercial fish juice. This lure was hung from a tree in the middle of a copse of thick vegetation that caused bears to use specific travel paths to investigate the lure. Ten single-catch hair snares were placed around the lure on these paths so a bear had to encounter ≥ 1 snare to reach the lure.

We defined a sample as all hairs collected from an individual hair snare. During a field check, tripped snares were collected, placed in individually labeled plastic bags, and brought back to camp. We replaced the hair snares with a clean snare. At the end of each day, we removed hairs from each snare and placed it in a uniquely numbered paper envelope that was air dried and then stored in a dry environment. We screened hair samples to eliminate samples that were obviously not from bears. Because of the overall relative scarcity of samples, we sent all samples that contained hair even if no obvious follicles were present.

In addition to hair samples, we collected tissue samples from bears live-captured for a separate part of this study for genetic analysis. These bears were collared during the study period and were included as a session in our capture-mark-recapture analysis.

Genetic Methods

We sent samples to a commercial genetics laboratory (Wildlife Genetics International, Nelson, BC) for DNA extraction and individual identification. For hair samples, we sent all samples with ≥ 1 follicle. Samples were screened with the G10J microsatellite to separate brown bears from black bears (*U. americanus*; D. Paetkau, Wildlife Genetics International, personal communication). An assignment test (Paetkau et al. 1995) was performed with the most complete set of microsatellite markers available, excluding G10J, to independently confirm the species designation originally based on G10J. For each brown bear sample, 7 microsatellite loci were analyzed to determine individual identity: G10J, G1A, G10B, G10H, G10M, G10U, Mu50 (Paetkau et al. 1998, Paetkau 2003). For the brown bear samples, if good values were obtained for all 7 loci, we considered the hair sample to have been successfully genotyped (Paetkau 2003). Recommendations to detect and eliminate genotyping errors from Paetkau (2003) were followed. All live-captured bears were evaluated at 8 additional microsatellite markers (MU59, G10C, CXX110, CXX20, G10L, G10D, G10P, G10X) for future population-level analyses.

Population Estimation

For the Bradfield Canal study area, we used Robust Design models in Program MARK (White and Burnham 1999) to estimate population size. We developed one encounter history for each bear. We entered hair snare detections as sessions 1-3, followed by whether GPS-collared bears in the sample were alive at the end of the year (session 4) and alive at the beginning of the next sample year (session 5). Finally, sessions 6-8 were hair detections in the second year. We assumed that any behavioral response to hair snares was negligible because snares were set along bear trails and did not utilize any lure or bait to attract bears. For lure stations, we assumed no behavioral response given that no reward was provided for visiting the snare site.

Robust design models incorporate 2 (or more) years of data and allow the addition of covariates (whether a bear was collared in our case) to produce more precise estimates than running each year separately. The robust design model estimated survival (*S*), population size (*N*), capture probability (*p*) and recapture probability (*c*). These models are also made to estimate parameters for immigration and emigration of animals into and out of the population over the study period. However, we were unable to estimate these parameters without another year of data and therefore, defined them to be 0. Survival estimated by this model is not true survival, but apparent survival in that it incorporates movement into and out of the defined population during the course of the study period. We obtained estimates for female, male, and total population size from the robust design model.

We were unable to incorporate between-bear heterogeneity in capture probability in the robust design model due to the small number of bears. To compare estimates that incorporate individual heterogeneity, we generated population estimates for each year (i.e., 2005 and 2006) of data separately in Program CAPTURE (Otis et al. 1987) from within Program MARK utilizing the jackknife model (M_h).

For the Unuk River data, we used closed capture models in Program MARK to generate a population estimate (White 2008). We entered hair snare detections as sessions 1-3, followed by whether GPS-collared bears in the sample were alive at the end of the year (session 4). We assumed that any behavioral response to hair snares was negligible because snares were set along bear trails and did not utilize any lure or bait to attract bears. For lure stations, we assumed no behavioral response given that no reward was provided for visiting the snare site. Within the closed capture framework, we compared models with constant *p* (M_0; Otis et al. 1987); time varying *p* (M_t); behavioral response to capture (M_b); and sex specific *p*.

We used the sample size-adjusted Akaike's Information Criterion (AIC_c) and AIC_c weights to evaluate relative support for each candidate model. We considered the model with the lowest AIC_c score to have the best fit (Burnham and Anderson 2002). We used changes in AIC_c values (ΔAIC_c) to compare models support. We averaged population estimates based on their support by the data as estimated by AIC_c weights to further account for model selection uncertainty (Burnham and Anderson 2002).

We computed a density for the brown bear population in the Bradfield Canal and Unuk River study areas by estimating the area used by these brown bears during the late summer season. We used location data from another phase of the project (Chapter 2) to determine the extent of the area occupied by the brown bear population during the late summer season, the period of the population estimate. Most of the salmon spawning occurred during the late summer. We defined the late summer seasons as 16 July – 15 September. We took all of the GPS points during the late summer season for radiocollared bears and plotted them in a GIS system. For the Bradfield Canal study area, we restricted the locations to south of Aaron Creek, north of the Bradfield Canal, and north of the ridgeline with the Unuk River drainage. We drew a concave polygon around the extent of these points because the bear movements were quite linear along the streams (Fig. 2). Thus, much of the uplands appeared to not be used. Also, we excluded all salt water. We considered this area (1,095 km^2) the part of the study actually sampled for the population survey (Fig. 2). In the Unuk River, we calculated a 100% convex polygon around all the points using the ArcGIS extension Hawthorne's Analysis Tools, essentially computing a collective home range area. Next, we buffered the polygon by 1 km to account for some movement outside of the polygon (Fig. 3). Because of the linear nature of the bear movements, we probably had little movement outside this polygon. We expressed density as the estimated number of brown bears per area.

RESULTS

Sampling Effort

During 2005, we deployed 137 hair snares on streams within the Bradfield Canal study area. We checked these snares on 21-22 July, 30-31 July, and 13-14 August for 3 hair sessions (session length = 7 days, 8 days, and 14 days, respectively; Table 1). We collected 181 hair samples, 5 of which were determined to not be bear hair and were discarded.

During 2006, we deployed 147 hair snares along bear trails and 40 snares at 4 lure sets (10 snares at each lure set) in the Bradfield Canal area. We checked these snares on 4-5 August, 8-12 August, and 29-31 August for 3 hair sessions (session length = 8 days, 7 days, and 20 days, respectively; Table 1). We collected 256 hair samples, 7 of which were determined to not be bear hair and were discarded.

During 2007, we deployed an average of 167 hair snares along streams and 40 snares at 4 lure sets (10 snares at each lure site) in the Unuk River study area. We checked these snares on 8-11 August, 17-21 August, and 27-31 August for 3 hair sessions (session lengths = 10 days; Table 1). We collected 313 hair samples, 7 of which were determined to not be bear hair and were discarded.

Genetic Analyses

During 2005 in the Bradfield Canal, we sent 176 hair samples for genetic analysis, of which 32 (18%) contained inadequate material to warrant extraction, 56 (32%) were set aside after they failed to produce high confidence data after 2 attempts, 50 (28%) were identified as black bears, and 38 (22%) were identified as brown bears (Table 1).

During 2006 in the Bradfield Canal, we sent 249 hair samples for genetic analysis, of which 17 (7%) contained inadequate material to warrant extraction, 108 (43%) were set aside after they failed to produce high confidence data after 2 attempts, 3 (1%) showed evidence of > 2 alleles consistent with a mixture of DNA from 2 individuals, 54 (22%) were identified as black bears, and 67 (27%) were identified as brown bears (Table 1).

In the Unuk River across sessions, we sent 306 hair samples for genetic analysis, of which 31 (10%) contained inadequate material to warrant extraction, 107 (35%) were set aside after they failed to produce high confidence data after 2 attempts, 4 (1%) showed evidence of > 2 alleles consistent with a mixture of DNA from 2 individuals, 120 (39%) were identified as black bears, and 44 (14%) were identified as brown bears (Table 1).

Mean observed heterozygosity across the 7 markers used to identify individual brown bears was 0.76. Given this observed variability and our sample size, 7 microsatellite markers should have provided appropriately low match probabilities for assigning individual identities (Paetkau 2003). To further investigate the probability of misidentification of individuals, all genotypes that matched at 5 of 7 markers (2MM-pairs) or at 6 of 7 makers (1MM-pairs) were solidly replicated to eliminate genotyping errors (D. Paetkau, personal communication; Paetkau 2003).

Population Estimation

Genetic analysis of the samples identified 21 unique brown bears in 2005 and 37 unique bears during 2006 in the Bradfield Canal, for a total of 49 unique bears (Table 1). We successfully genotyped 11 brown bears that had been handled in the Bradfield for research purposes. Of the individual bears identified with hair from snares, 13% had been live-captured at least once in the Bradfield.

We estimated the population size for the Bradfield Canal area was 30 brown bears (95% CI = 27 – 38; 8 males, 95% CI = 8 – 15; 21 females, 95% CI = 19 – 28) in 2005 and 48 brown bears (95% CI = 45 – 58; 14 males, 95% CI = 13 – 21; 34 females, 95% CI = 31 – 43) in 2006. Estimates that incorporated individual heterogeneity were similar for 2005 (9 males, 95% CI = 9 – 22; 39 females, 95% CI = 29 – 59) and 2006 (17 males, 95% CI = 14 – 29; 53 females, 95% CI = 41 – 75), but with much greater variability around the estimate. Given a sampled area of 1,094 km^2, the density of brown bears in the late summer would be about 27 bears/ 1000 km^2 with a 95% CI = 25 – 35 bears/ 1000 km^2 in 2005 and 44 bears/ 1000 km^2 with a 95% CI = 41 – 53 bears/ 1000 km^2 in 2006.

In the Unuk River, 29 unique brown bears were identified during 2007 (Table 1). We genotyped 23 brown bears that had been captured in the Unuk for research purposes. Of the individual bears identified with hair from snares, 39% had been live-captured at least once in the Unuk. We estimated the population size to be 45 brown bears (95% CI = 30 – 60; 12 males, 95% CI = 9 – 22; 32 female, 95% CI = 24 – 53). Given a sampled area of 877 km^2, the density of brown bears in the late summer would be about 51 bears/ 1000 km^2 with a 95% CI = 34 – 68 bears/ 1000 km^2.

DISCUSSION

Our study provides the first area-specific population estimates for the southern mainland of southeast Alaska. These results confirm that bear numbers in these areas are much lower than in populations on the ABC islands (Miller et al. 1997, Flynn et al. 2007). We recorded brown bear densities ranging from 27 to 51 bears/1000 km^2 compared with density estimates on Admiralty and Chichagof islands from 399 to 440 bears/1000 km^2 (Miller et al. 1997). Across Alaska, Miller et al. (1997) recorded brown bear densities ranging from 10.1 to 551 brown bears/1000 km^2. Thus, the estimates for the Bradfield and Unuk are on the lower side for brown bear populations in Alaska. If we computed our densities using the total land area in the drainages, then our calculated population densities would be much lower and among the lowest in the state.

On the ABC islands, some habitats important to bears are less common on the mainland (Schoen and Beier 1990, Titus et al. 1999, Flynn et al. 2007). Most importantly, the mainland has fewer salmon-spawning streams. The availability of spawning salmon is directly related to population density in brown bears (Hilderbrand et al. 1999b), and probably translates to fewer bears on the mainland than in island populations in southeast Alaska.

We estimated fewer bears in the Bradfield Canal study area in 2005 than in 2006. Across our sampling years, our study area boundary was open to bear movement. While we did not have movement into or outside of our study area during our closed-capture sessions, it implies that the estimate we generated relates to the superpopulation of bears (i.e., full- and part-time resident bears) using the Bradfield Canal area during 2005 – 2006 (Crosbie and Manley 1985, Kendall et al. 2008).

Understanding the way that bears use the study area and surrounding landscape requires understanding how bears utilize available resources. One of the most important resources to coastal brown bears is spawning salmon (Hilderbrand et al. 199b). The availability of salmon to bears is a dynamic process involving the number of salmon available (i.e., strength of a yearly cohort), climatic conditions (e.g., rainfall), and the physical environment (e.g., the amount of spawning habitat). Each stream varies in the species of salmon that spawn there, the number of fish that return to spawn, and the amount of spawning habitat and fishing habitat available. Thus bears can visit different streams depending on the abundance and availability of salmon there.

Adult male bears usually have large home ranges that can encompass many different salmon streams. They can choose among these streams as to where they get their salmon resources. One bear we monitored with a GPS collar left the study area prior to the hair sampling in 2005 to visit 3 widely spaced salmon streams. He remained outside the area until just prior to the hair sampling in 2006. During 2006 he stayed on 1 stream reach for all 3 sessions and was hair captured each time. This provides an example of bears that may have been missed in the first sampling year, but captured in the second year.

One other way that numbers could have increased between years involves immigration. We captured hair from a female bear, originally identified outside our study area in a different study (D. Paetkau, personal communication), that apparently immigrated into our study area. In addition, a young male bear from that same study (D. Paetkau, personal communication) was live captured in the Unuk River study area; another apparent immigrant.

Beyond bears leaving the study area across study years, the possibility remains that bears within the area are not detected during our sampling, and thus were not counted. This was the case with a GPS-collared adult female that visited 4 hair snare stream segments over 3 sessions, but was never captured (i.e., never identified in the hair samples). During late summer in southeast Alaska, brown bear diets are dominated by salmon, but also contain sedges, skunk cabbage, and various berries (e.g., devil's club, blueberry, current; McCarthy 1989). Many of these alternate foods are found in or near riparian areas where bears are also foraging on salmon. Thus, bears can visit sampling areas (i.e., stream reaches with hair snare), but, because they are feeding on alternate foods, are not interacting with hair snares.

Social dominance also plays an important role in determining the amount of time individual bears spend on streams (Gende and Quinn 2004). Larger, more-dominant bears visit streams more often and spent more time on the streams while subordinate bears might visit streams less or spent less time on the stream (Gende and Quinn 2004). Within the dominance hierarchy of bears, sex, age, and reproductive status all seem to play a role in determining a bear's level of dominance. The most dominant bears on a stream are almost always large, adult males. Younger bears are usually low on the dominance hierarchy and may avoid some streams so not to interact with more dominant individuals. When females are defending cubs, they may avoid some streams due to the presence of large adult male bears (Ben-David et al. 2004). Conversely, these female bears may visit such streams when not with cubs because they do not need to be as vigilant.

When a bear does visit a salmon stream and encounters a hair snare, there remains a process that leads to the identification of that bear that is affected by external variables. Does the snare snag a good sample of hair that contains hair follicles? If it does, it then can depend on the weather on how well that sample is preserved. DNA can degrade rapidly in moist conditions, such as the rainforest environment of southeast Alaska. Additionally, during the late summer the prevailing weather patterns begin to shift and bring extended rainstorms through the area. Thus, the weather during the session can affect the DNA from snagged hair. Of the hair samples we sent for identification, approximately 37% failed to produce high confidence data which could be the result of degraded DNA.

Given the remote character of the landscape, we relied on sampling along streams during the time when salmon return to spawn. A key assumption related to using this method to generate a population estimate for the study area was that all bears visit salmon streams that we sampled during this time period, and thus have a chance of being detected. If some bears do not visit the segments of streams that we set snares upon, we may underestimate the numbers of bears in the area. Data from GPS-collared bears over multiple study areas in southeast Alaska (unpublished data) shows that all males visit salmon streams during the spawning season, but a small number of females (≤ 2% of collared females) may not visit salmon streams. Ninety-one percent (10 of 11) of GPS collared bears in our study areas at the start of hair sampling visited at least one salmon stream with hair snares, and all at least visited lure sites. Thus, we feel these data support this assumption.

The assumptions of capture-mark-recapture analysis included error-free genetic marking, lack of a behavioral response to our snares, homogeneous capture probability among individuals, and population closure. Our relatively sparse dataset (in terms of capture sessions) and the low number of bears in these populations limited our ability to test and evaluate these assumptions.

We assumed error-free genotyping and correct identification of individuals. The laboratory where we send our hair samples employs a rigorous protocol for detecting and eliminating genotyping errors (Paetkau 2003). Thus, we feel that any genotyping errors are detected. If not, the relatively large confidence intervals around our estimates probably absorb any uncertainty.

The use of non-baited, non-invasive hair snares limits the effect that sampling could have on bears, and thus the chance of there being an altered capture probability of bears previously captured. The single-catch hair snares utilize the natural attractant of spawning salmon and are placed such that they are unobtrusive to the passing bear. In addition, we set snares using gloves to minimize human smells.

We cannot eliminate the possibility of heterogeneity in capture probability among bears. Using an analysis technique that incorporated heterogeneity in capture probability provided similar estimates of bear numbers, but with larger confidence intervals. Regardless, we think the 2006 Bradfield Canal estimate is the more likely number of bears found in that study area and is the estimate we recommend to manage the brown bear population in this area.

MANAGEMENT IMPLICATIONS

We provide estimates of bear numbers for 2 areas of the southern mainland in southeast Alaska. The Alaska Department of Fish and Game has set aside harvest guidelines for brown bears of ≤ 4% of a bear population killed by human causes (i.e., hunting, defense of life and property) and ≤ 1.5% of female bears in the population. For both study areas, these guidelines are low (2 bears of any sex; < 1 female per regulatory year). Because of this, the evidence suggests that no further guide/outfitter special-use or big game hunting permits are warranted for these areas. Because the low bear numbers here and probably throughout the mainland of southeast Alaska, the guide/outfitter industry should not anticipate spilling over from the dense island bear populations to new hunt areas on the mainland. In areas where there is concern for low numbers of brown bears, hunts should be monitored carefully so as not to exceed guidelines.

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FIGURES

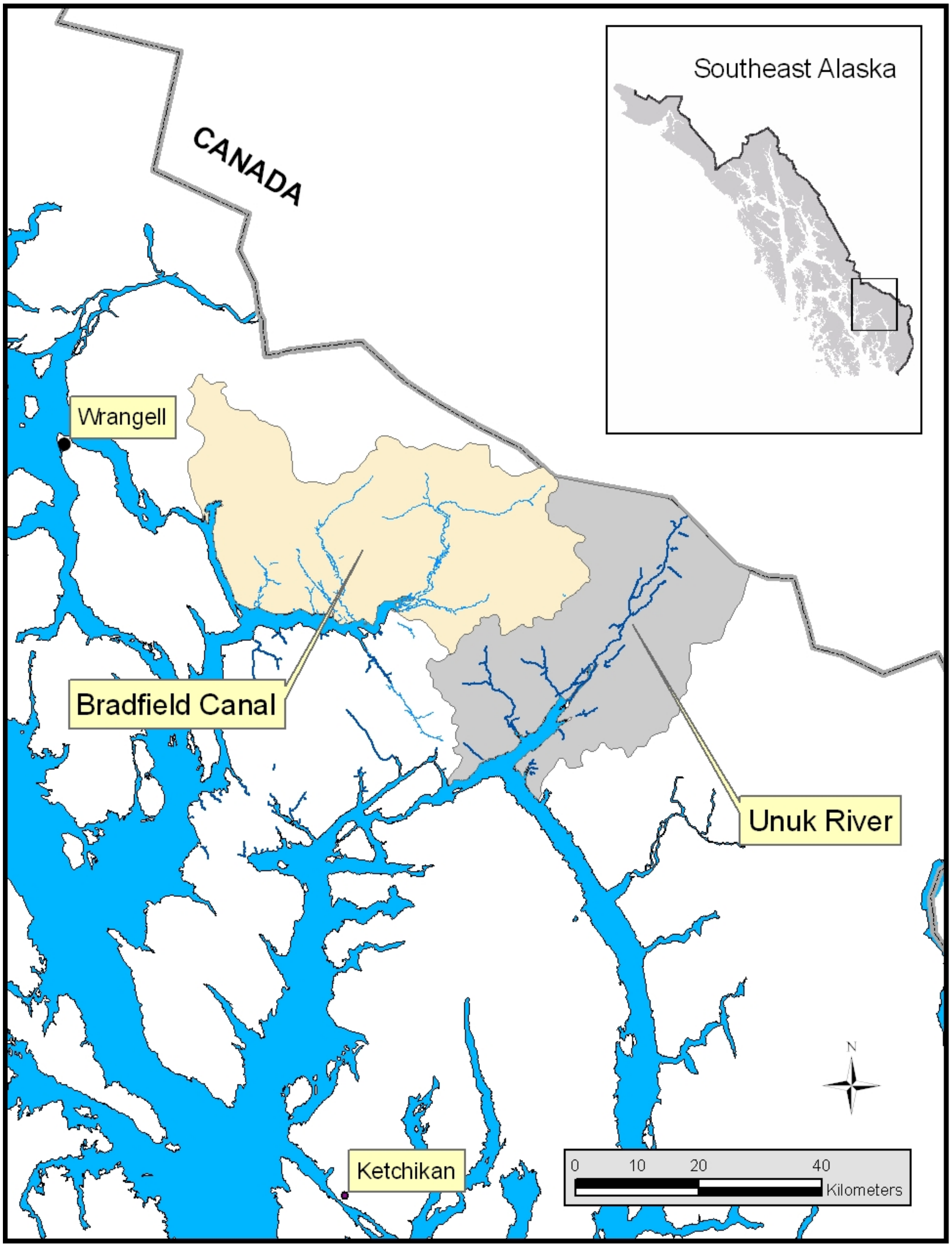

Figure 1. Location of brown bear study areas on the southern mainland coast of Southeast Alaska.

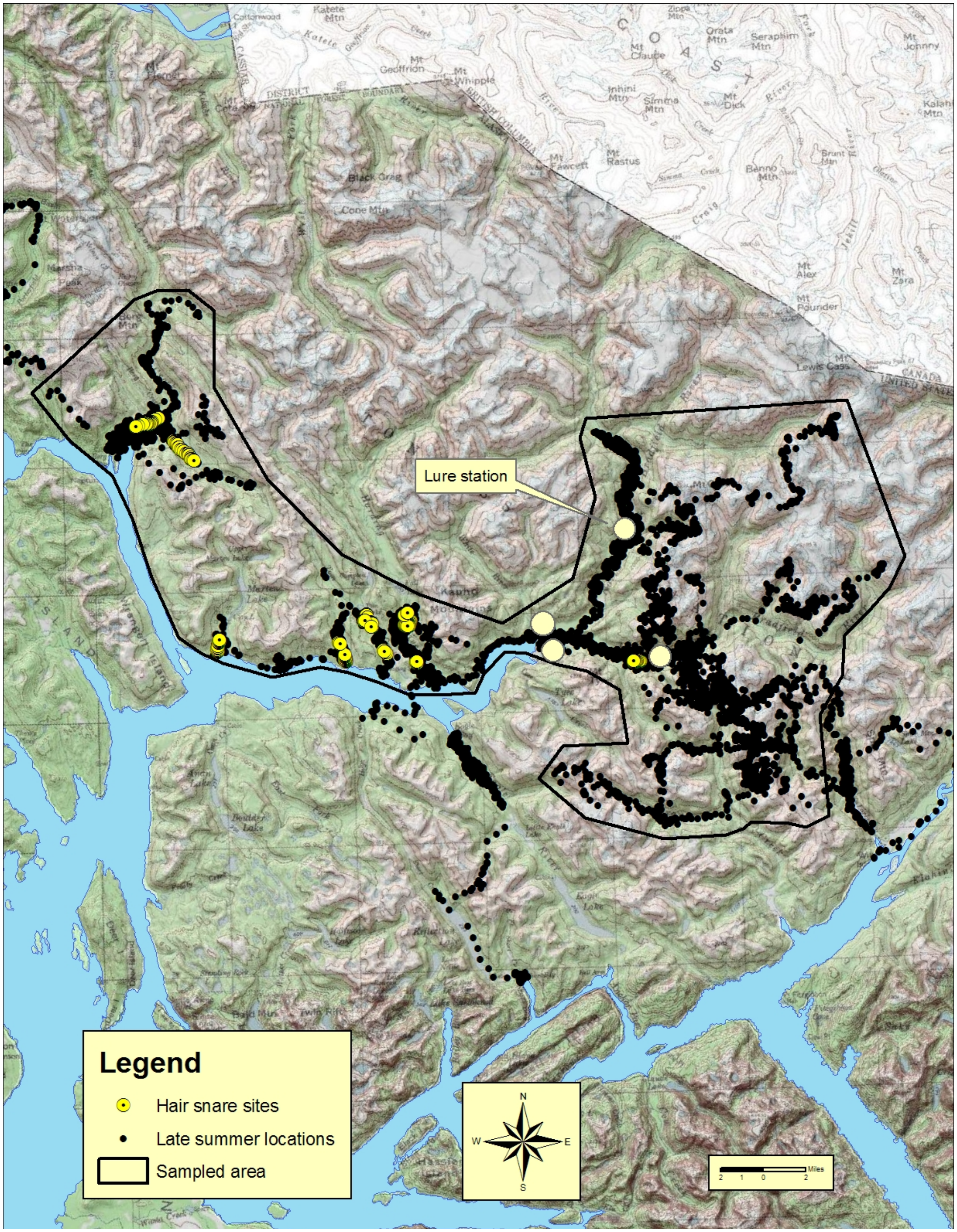

Figure 2. Locations of hair snare sites, GPS locations for radiocollared brown bears during the late summer, and area considered sampled in the Bradfield Canal study area, Southeast Alaska during 2004 – 2007.

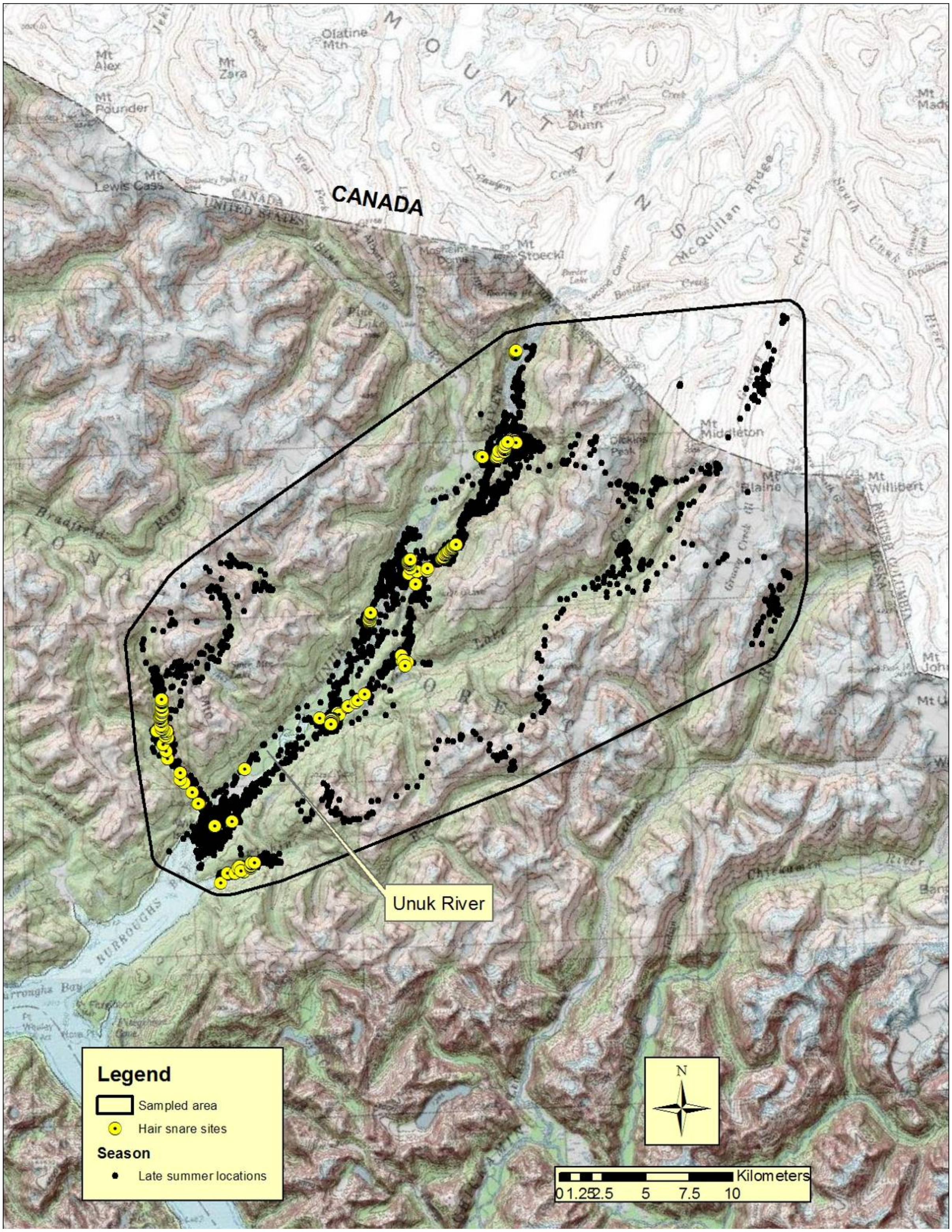

Figure 3. Locations of hair snare sites, GPS locations for radiocollared brown bears during the late summer, and area considered sampled in the Unuk River drainage, Southeast Alaska during 2007.

TABLES

Table 1. Brown bear hair snare results from the Bradfield Canal and Unuk River, Southeast Alaska 2005 – 2007.

Study Area	Year	Session	Dates	No. site Stream	No. site Lure	Samples	No. unique bears M	No. unique bears F	New bears w/in year M	New bears w/in year F	New bears w/in study area M	New bears w/in study area F
Bradfield	2005	1	14 Jul – 22 Jul	137	~	51	1	11	1	11	1	11
		2	21 Jul – 31 Jul	137	~	64	3	2	3	1	3	1
		3	30 Jul – 14 Aug	137	~	61	4	4	2	3	2	3
	ξ			137	~	59	3	6	2	5	2	5
	Total			411	~	176	8	17	6	15	6	15
	2006	1	25 Jul – 5 Aug	147	4	88	7	15	7	15	5	11
		2	4 Aug – 12 Aug	147	4	67	7	8	4	4	4	3
		3	11 Aug – 31 Aug	147	4	94	4	11	2	5	2	3
	ξ			147	4	83	6	11	4	8	4	6
	Total			441	12	249	18	34	13	24	11	17
	Grand Total			852	12	425					17	32

Table 1 Continued.

Study area	Year	Session	Date	No. site Stream	Lure	Samples	No. unique bears M	F	No. new bears M	F	New bears in study area M	F
Unuk	2007	1	29 Jul – 11 Aug	149	4	104	7	10	7	10	7	10
		2	10 Aug – 21 Aug	160	4	86	2	7	1	5	1	5
		3	20 Aug – 31 Aug	192	4	120	3	8	1	5	1	5
	ξ			167	4	77	4	8	3	7	3	7
	Total			501	12	232	12	25	9	20	9	20