Habitat use and movements of river otters at Kelp Bay, Baranof Island, Alaska

HABITAT USE AND MOVEMENTS OF RIVER OTTERS AT KELP BAY, BARANOF ISLAND, ALASKA

A

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By

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HABITAT USE AND MOVEMENTS OF RIVER OTTERS

AT KELP BAY, BARANOF ISLAND, ALASKA

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ABSTRACT

Habitat use and movements of river otters (Lutra canadensis) were studied at Kelp Bay on Baranof Island in southeastern Alaska from January 1982 to January 1983. River otters were captured and transmitters surgically implanted in 12. Otters used primarily uneven-aged old-growth conifer forest within 30 m of shore throughout most of the year. Otters preferred forest areas adjacent to steep shores of solid or large rock. Natal dens used by four adult females were located in uneven-aged old-growth forests and were greater than 0.25 km from shore. This study determined that river otters in that part of southeastern Alaska bred and gave birth during May. Home range was considered the length of coastal shoreline used. Four family groups occupying adjacent but non-overlapping areas of shore showed relatively little seasonal variation in home range length. The respective shores used by each family group remained the same throughout all seasons.

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INTRODUCTION

River or land otters (Lutra canadensis) are one of the larger members of Mustelidae and are well adapted for the coastal environment of southeastern Alaska. They commonly travel in the water along the shores and are frequently observed in groups. River otters also travel overland, but usually restrict their terrestrial habitat use to a narrow strip along shore (Larsen 1983, Melquist and Hornocker 1983).

Though closely related to the European otters (Lutra lutra), the river otters of North America north of the Rio Grande River, are the species Lutra canadensis. This species was originally separated into 18 subspecies by Hall and Kelson (1959) with five of these subspecies occurring in Alaska and three of those in southeastern Alaska. Subsequently Hall (1981) described only seven subspecies of L. canadensis in North America. Three of these occur in Alaska: L. c. kodiacensis on the Kodiak Island group, L. c. mira in southeastern Alaska and L. c. pacifica throughout the rest of the state. I assumed otters at Kelp Bay were L. c. mira.

River otter distributions are probably related to habitat availability. Though adapted for aquatic travel and foraging, otters need terrestrial areas adjacent to aquatic habitat for resting and natal den sites.

Historically, river otters occurred throughout most of North America. They are now found in less than 33% of their former range in the contiguous United States, largely a result of habitat alteration, pollution and in some areas, intensive, localized trapping (Rust 1946, Nilsson and Vaugh 1978). A 1976 survey (Deems and Pursely 1978) concluded that river otters occurred in 44 states and 11 Canadian provinces and territories, and received total protection in at least 17 states.

The pelts of river otters have always been an important item of the fur trade in North America. In 1839, the mainland of southeastern Alaska was leased to the Hudson's Bay Company from the Russia-America Company for an annual fee of 2000 river otter pelts (Gruening 1954). While the size and dynamics of river otter populations in Alaska have not been determined, the harvest has been recorded for over 100 years. In recent years, approximately 2000 river otters each year have been taken in the state. These numbers have fluctuated within fairly narrow limits and there is no indication that otter populations in the state are declining (Skoog 1978).

River otters were placed on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1977 (Federal Register 42:10462-10488, USDI 1982). River otters were included as one of "those species not necessarily now threatened with extinction, but which may become so unless trade in them is subject to strict regulation". This listing required federal permits for international shipment of otter pelts.

The State of Alaska maintained that river otters in Alaska were not threatened by harvest or habitat alterations. The Alaska

Department of Fish and Game (ADFG) petitioned the U. S. Fish and Wildlife Service (FWS) and requested that river otters be redesignated (Skoog 1978). The status of river otters in regards to CITES was recently changed to Appendix IIb, which includes species thought to be threatened or endangered "...because of similarity in appearance to other listed species..." (USDI 1983). Permits for exporting otters pelts are still required (USDI 1984).

The Alaska National Interest Lands and Conservation Act of 1980: PL 96-487 (ANILCA) mandated that 4.5 billion board feet of timber be made available for harvest each decade from Tongass National Forest (TNF) in southeastern Alaska. It also provided for the transfer of Forest land to the State of Alaska (cumulative total up to 97,200 ha) and to regional native corporations (between 222,700 and 242,900 ha). Estimated timber harvest from these transferred lands would be between 225 and 400 million board feet each year (Lentfer et al. 1980).

Harvest of old-growth forests has far reaching implications for river otters and other wildlife. Only recently has the importance to wildlife of uneven-aged old-growth forest become evident (Kessler 1979, Wallmo and Schoen 1980, Schoen et al. 1981 and Larsen 1983).

Federal actions prior to ANILCA recognized wildlife resources as a major component of the TNF and other national forests. The Federal Land Policy and Management Act of 1976: PL 94-579 (FLPMA) required that Forest Service planning on National Forests be conducted by an interdisciplinary approach and must address all resources including "...timber, range, fish, other wildife and water."

This study was undertaken to collect information about the ecology of wild river otters in southeastern Alaska. The primary emphasis was to determine what habitat river otters use and how they use it. A better understanding of habitat needs of river otter in southeast Alaska will be helpful to resource management agencies and the timber industry in formulating resource development and management plans. Gaining an understanding of otter and habitat relations may allow managers to reduce impacts on otters and their habitats, and attempt to establish mitigation measures should negative impacts occur. Specific objectives of this study were:

1. To gain a general understanding of life history of river otters in Kelp Bay, Baranof Island, Alaska.

2. To determine seasonal habitat use, distribution and movement patterns of river otters in Kelp Bay.

3. To determine habitat characteristics of river otter natal den sites.

STUDY AREA

The study was conducted at Kelp Bay (Latitude 57° 17' N., Longitude 134° 55' W.) on the northeast corner of Baranof Island, southeastern Alaska. Kelp Bay is approximately 112 km southwest of Juneau and 37 km northeast of Sitka. The bay covers approximately 70 km^2 and consists of three major arms and a smaller bay called The Basin. Kelp Bay is bounded by Baranof Island to the south and west, Chatham Strait to the east and Catherine Island on the north (Fig. 1). Most of the field work was conducted in the area of South Arm, Pond Island, The Basin and South Point. Baranof Island is within the administrative unit of the Sitka Ranger District, Chatham Area, Tongass National Forest. The research camp consisted of Forest Service administrative cabins.

Baranof Island (4237 km^2) is the fourth largest island in the Alexander Archipelago and consists of belts of sedimentary and metamorphic rock (greenstone, schist, phylitte, graywacke, slate, argillite and conglomerate) with scattered lenses of volcanic origin (Selkregg, 1976). The well exposed bedrock of the Kelp Bay shore was used by Berg and Hinckley (1963) for the type area (the Kelp Bay Group) to represent the most widespread assemblage of rock on northern Baranof Island. The Kelp Bay Group was probably formed during the Triassic. Unconsolidated materials include volcanic ash, glacial debris and alluvium (Berg and Hinckley 1963).

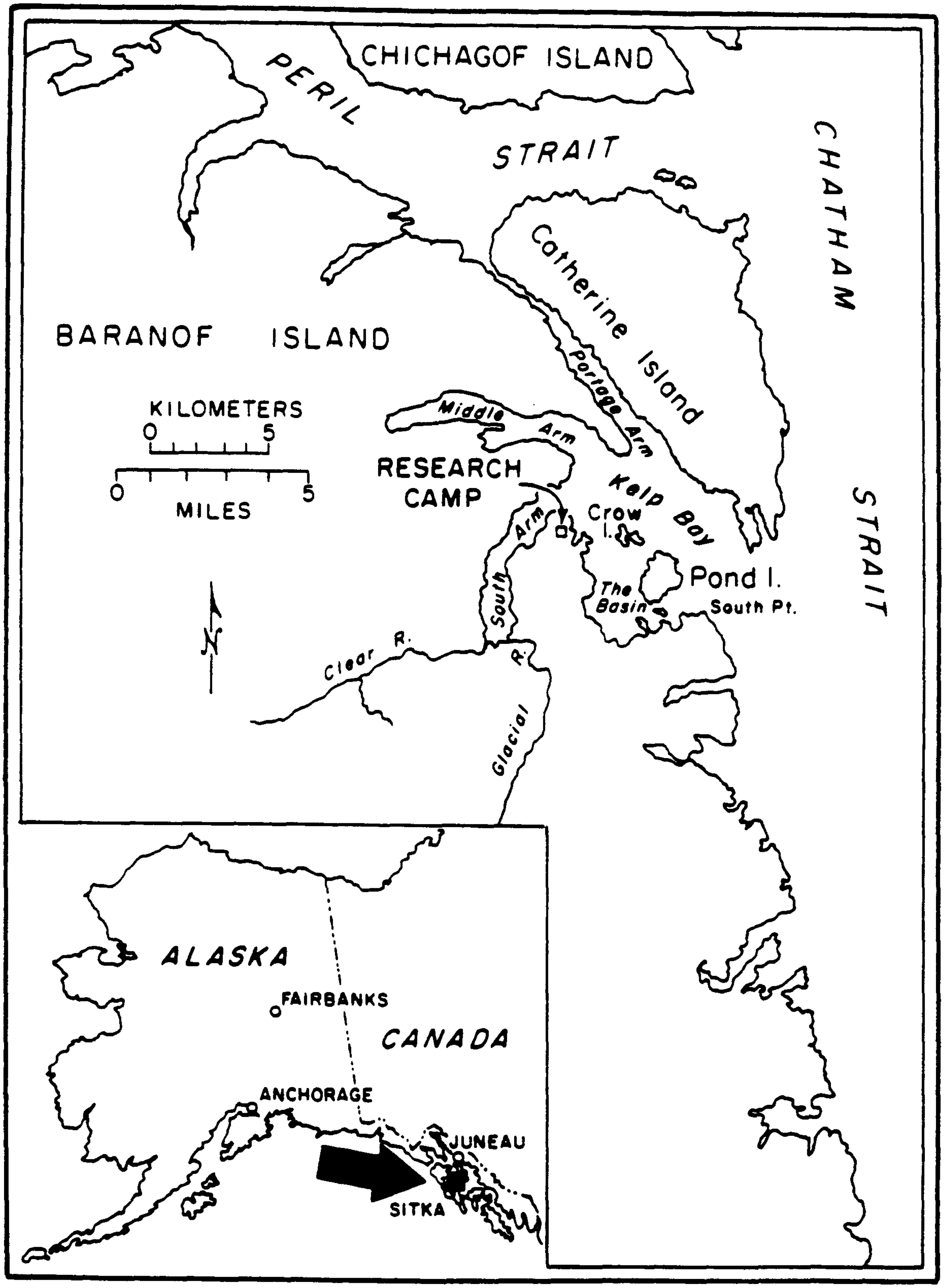

Figure 1. Kelp Bay study area.

Major land forms that characterize Kelp Bay include: large peninsulas separating bodies of salt water, sand and mudflat estuarine areas at mouths of major freshwater streams and mountains rising to 1200 m.

Lower parts of the mountains show evidence of glacial action and the upper reaches exhibit angular, unworn peaks and ridges. Year-round snowfields occur on the higher peaks.

Snowmelt and frequent rain provide water for year-round flow in numerous streams. Bodies of freshwater are relatively few and limited to small ponds, probably a result of the steep topography and shallow soil.

While many of the areas close to shore rise at a moderate grade, the walls of the fiord-like South Arm rise abruptly from sea level to 1000 m within 1 km from shore. Water depths greater than 180 m occur in the area of a northwest striking fault southwest of Catherine Island (Berg and Hinckley 1963). Depths greater than 90 m occur in each of the arms, a result of scouring and drainage from the last major glaciation. Most of southeastern Alaska has experienced geologic uplift since that period (Selkregg 1976).

Shorelines contain a mixture of steep rock cliffs, boulders, sand and cobble beaches. Rock shoals frequently occur out from the many points of land. Most shores are covered with rockweed (the algae *Fucus* spp.) except areas subject to frequent wave action. The marine area of Kelp Bay is subject to semi-diurnal mixed tides (Ricketts and Calvin 1968, Carefoot 1977). There are two high and two low tides each day, but the heights between each high and each low are unequal. The timing of each tidal phase progressed approximately 50 minutes each day (corresponding to the length of the lunar day) (Woodworth and Haight 1927) and tides ranged from 6.2 m above to 1.5 m below mean sea level (MSL) for 1982 (Anon. 1981).

The climate of Kelp Bay is typical for southeastern Alaska: high year-round precipitation and temperatures moderated by the coastal environment. Temperature and precipitation for local areas are dependent upon altitude and exposure to weather systems. Minimum and maximum temperatures were recorded daily at the research camp during this study (Appendix A). Maximum temperature recorded was 21°C (July 24, 25) and the minimum was -12°C (February 23). During the winter months ice covered the southern half of South Arm and the western half of Middle Arm. Ice formation resulted from low temperatures, heavy snowfall and freshwater from the rivers at the head of each of these arms overflowing the saltwater. Periods of low temperatures and calm water temporarily allowed ice to form on smaller bays, coves and The Basin.

Rainfall was measured in nearby Kasnyku Bay by the ADFG, Fisheries Rehabilitation, Enhancement and Development (FRED) Divison at the Hidden Falls Hatchery (Appendix B). Monthly rainfall ranged from 482 mm in October to none during June. Frequent heavy snowfalls occurred from January through March. Snow depths were recorded at four locations near the research camp (Appendix C). Snow remained at tideline until early May in 1982, though this may have been an unusual occurrence (J. Cochran, pers. comm.)

The prevailing winds on the east side of Baranof Island come from the southeast, the direction from which the most severe storms come. Winds during the fall can reach 148 km/hr on nearby Chatham Strait (L. Johnson, pers. comm.), but the protection provided by the hills to the south and southeast prevent such strong winds in most of Kelp Bay.

The high precipitation and moderate temperatures of southeastern Alaska provide suitable growing conditions for coniferous forests. The primary large tree species of the Kelp Bay area are mixed stands of uneven-aged old-growth western hemlock (Tsuga heterophylla), Sitka spruce (Picea sitchensis), and yellow cedar (Chamaecyparis nootkatensis). These forests occur as narrow bands between the water and mountains in steep areas, and in areas of more gradual slope, as extensive woodlands from shore up through broad valleys. Major understory plants include devil's club (Oplopanax horridus), rusty menziesia (Menziesia ferruginea) and blueberry (Vaccinium spp.) (Selkregg, 1976, USDA 1980). Neiland (1971) and Viereck and Little (1972) discussed the vegetation of muskegs and alpine areas of southeastern Alaska. Thickets of shrubs including alder (Alnus spp.), thimbleberry (Rubus parviflorus) and salmonberry (Rubus spectabilis), occur in areas of recent soil or vegetation disturbance, such as landslides, clearcuts or logging roads (Viereck and Little 1972). The Clear River valley contains a mixture of the above mentioned species as well as black cottonwood (Populus trichocarpa) and willow (Salix spp.). Description of specific sites are included in the section entitled Habitat Use.

Terrestrial mammals observed in the Kelp Bay area included: Mountain goat (Oreamnos americanus), Sitka black-tailed deer (Odocoileus hemionus), brown bear (Ursus arctos), river otter, pine marten (Martes americana), mink (Mustela vison), red squirrel (Tamiasciurus hudsonicus) and Sitka deermouse (Peromyscus sitkensis). Mammals reported for Baranof Island but not observed during this study include the little brown bat (Myotis lucifugus), tundra vole (Microtus oeconomus), ermine (Mustela erminea), Norway rat (Rattus norvegicus), and the masked (Sorex cinerus) and dusky (Sorex monticolus) shrews (MacDonald 1980, S. MacDonald, pers. comm., L. Johnson, pers. comm.). Recent evidence of beaver (Castor canadensis) was found on Pond Island (D. Magnus, pers. comm.) though no beavers were actually observed. Present on other islands in southeastern Alaska, but notably absent from Baranof Island are wolf (Canis lupus), black bear (Ursus americanus) and wolverine (Gulo gulo). Animals introduced to Baranof Island include mountain goats, marten, red squirrel and beaver (Burris and McKnight 1973).

Marine mammals observed in Kelp Bay during this study included Humpback (Megaptera novaeangliae) and killer (Orcinus orca) whales, northern sea lions (Eumetopias jubatus), harbor seals (Phoca vitulina), Dall's (Phocoenoides dalli) and harbor (Phocoena phocoena) porpoise and Pacific white-sided dolphin (Lagenorhynchus obliquidens). On September 19, 1982 a male northern elephant seal (Mirounga angustirostris) was observed in Chatham Strait, just outside the entrance to Kelp Bay. At present, no sea otters (Enhydra lutris) are known to occur in the Kelp Bay area.

Bald eagles (Haliaeetus leucocephalus) commonly nested along the forested shoreline, and concentrations commonly occurred near streams when salmon were spawning. On August 9, 1982 a minimum of 94 eagles was counted on the flats at the southern end of South Arm near the mouth of Clear and Glacial Rivers. Numerous passerines, waterfowl and waterbirds occur in the area (Kessel and Gibson 1978, Armstrong 1981).

Fish species of the area include four species of Pacific salmon: King (Oncorhynchus tshawytscha), silver (O. kisutch), chum (O. keta) and pink (O. gorbuscha). Dolly Varden (Salvelinus malma) occur in both salt water and the freshwater streams in the area (Armstrong 1963, Blackett 1968). Cutthroat trout (Salmo clarki clarki) are present in freshwater ponds and streams. Other marine fish of the area are those which normally occurred throughout southeast Alaska (Hart 1973).

The abundant natural resources of the Kelp Bay area supported people prior to white settlement in Alaska. An archeological site at Hidden Falls in nearby Kasnyku Bay indicated three periods of prehistoric occupation: 1600 to 3500 years, 3700 to 4000 years and 10,000 years ago (Stanford et al. 1980). Evidence of more recent use included cedar trees from which the bark had been stripped within the last century. Residents from native villages in the area reportedly harvested herring (Clupea harengus) roe in Kelp Bay in the recent past (B. Bauder, pers. comm.).

From 1927 to 1952 a water-powered sawmill was operated at Hidden Falls (Harris and Farr 1974). Numerous stumps along the shore of Kelp Bay indicate timber was selectively harvested during this period by a method referred to as "hand-logging" (Harris and Farr 1974). It is not clear how much, if any, of the timber cut in Kelp Bay went to the Hidden Falls mill. In 1976 and 1977, 4.17 km^2 were clear cut in Kelp Bay (Fig. 2) for pulp and lumber production.

The Environmental Impact Statement for the 1981-85 Timber Sale Operating Plan (USDA 1980) indicated that between 5.94 and 6.43 km^2 would be cut in the Kelp Bay area, mostly on Catherine Island and Portage Peninsula. By spring 1984, none of the timber delineated in the Kelp Bay area by the 1981-85 Timber Sale Operating Plan had been cut.

Information regarding the take of furbearers in Kelp Bay is fragmentary. Animals in the area taken for fur are usually limited to marten, mink and river otter. The late Fred Manley reported taking over 100 river otters from Kelp Bay in one season (Manley, pers. comm.). Evidence of past otter trapping activity found during the study included trap anchor wire embedded in trees and long abandoned, heavily rusted traps in areas commonly used by otters. Limited fur trapping in Kelp Bay occurred during the time the study was conducted, but few animals were known to have been taken. Present trapping regulations for the State of Alaska allow taking furbearers in this area between December 1 and February 15.

Sport hunting for brown bear and deer is common in Kelp Bay. The present take of deer is unknown, but 73 brown bear have been reported taken since 1960 (L. Johnson, pers. comm.).

Commercial fishing occurs in Kelp Bay for salmon, shrimp, halibut

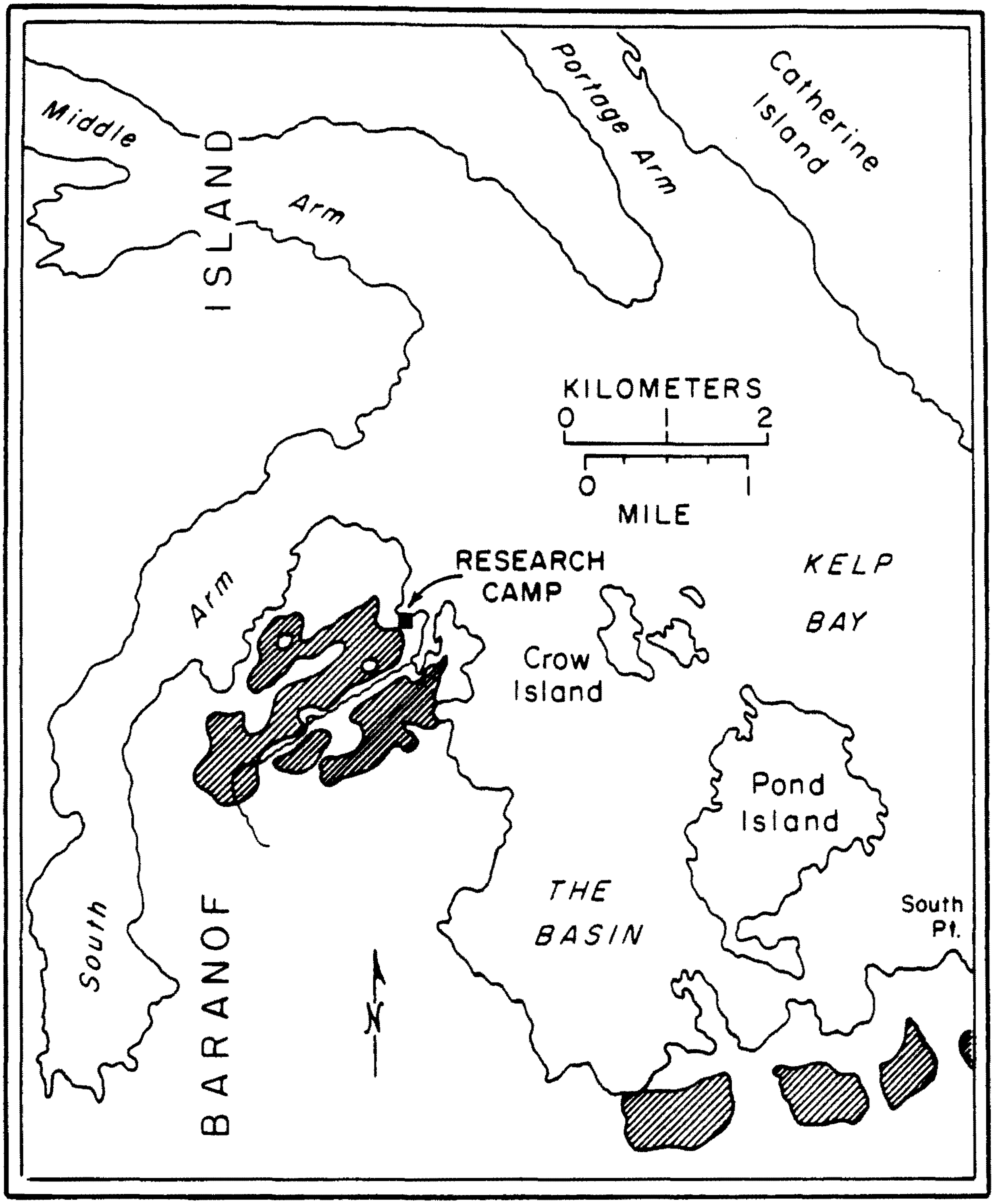

Figure 2. Clear cut areas near The Basin at Kelp Bay, Alaska. Cross-hatching indicates areas cut in 1976 and 1977.

(*Hippoglossus stenolegis*), and dungeness (*Cancer magister*), tanner (*Chionoecetes* spp.) and king (*Paralithodes camtschatica*) crab. Runs of salmon in the major streams support a sizable seine fishery. Records since 1960 indicate peak escapement counts for Clear River averaged 14,256 pink and 13,374 chum salmon (ADFG, Commercial Fish Division, unpublished records). Kelp Bay is also an area of active sport fishing for the above mentioned species as well as recreational boating. Many areas in Kelp Bay are protected and relatively shallow, making excellent anchorages and allowing extended stays.

METHODS

Capture and Immobilization

Otters were captured with Hancock live-traps (Hancock Trap Co., Hot Springs, SD) or steel leg-hold traps (3N Newhouse, 4 Victor and 48 Newhouse). The effectiveness of these traps for capturing otter has been reported by Northcott and Slade (1976), and Melquist and Hornocker (1979). Traps were placed in frequently used otter trails and entrances to burrows, then camouflaged with snow, moss, soil or grass. All traps were checked at least daily, with the leg-holds checked morning and evening. The term "trap-night" is used to describe the amount of trapping effort conducted and means one trap set overnight.

Otters found in traps were immobilized with a mixture of ketamin hydrochloride (Ketaset, Bristol Laboratories, Syracuse, NY) and xylazine hydrochloride (Rompun, Chemagro Agricultural Chemicals, Kansas City, MO). Dosages of 0.4 to 0.8 ml Ketaset and 0.1 to 0.3 ml Rompun were used on the basis of the relative size of the captured otters, with larger animals receiving larger doses.

The drugs were administered intramuscularly. When caught in a Hancock trap, the otter was pressed against one side of the trap by stepping on the collapsible side of the trap and the drug was injected with a hand-held syringe. Otters caught in leg-hold traps were covered with a large landing net and the drug injected by either a hand-held syringe or a syringe mounted on a jabstick. Immobilized otters were transported by boat from the capture site to the research camp. Otters captured in Hancock traps were transported in the trap, those caught in leg-hold traps were removed from the trap then wrapped in a landing net. All otters were covered with a plastic tarpaulin to prevent chilling. Additional injections of the immobilizing drugs were required upon arrival at the research camp before the otter could be safely handled. Injections of 500,000 to 750,000 units of penicillin were given to prevent capture related infections.

At the research camp, otters were weighed and measured, then placed in a 1.2 x 0.6 x 0.6 m wood and hardware cloth holding cage until surgery. The captive otter were provided fish and water after recovering from the effects of the drug. All captured otters fed freely while in captivity.

Age determination

Captured otters were aged as adults or pups based on toothwear, body size and season of capture. Pups were born during early May (See Reproduction) and were easily recognized during the summer and fall by their small size and unworn teeth. A pup's age when captured was estimated as the amount of time between early May and date of capture. Adults showed evidence of tooth wear on incisors and canines and body weights were above 8.5 kg.

Biotelemetry

Transmitters

Implantable transmitters were obtained from Telonics (Mesa, AZ). Each cylindrical transmitter package was 95 x 33 mm, weighed 85 to 90 g and was encapsulated in a biologically inert material. These transmitters operated in the 150 to 151 MHz frequency range with an expected operating life of 12 to 24 months. Maximum range of reception was about 5 km with the usual expected range about 1 km.

Surgical Procedures

When an otter was captured, ADFG personnel were notified, who then contacted Burgess Bauder, DVM, in Sitka. Dr. Bauder performed the implant surgery at the research camp. The procedures described by Melquist and Hornocker (1979) were generally followed, but there were several departures from their techniques. The procedures used at Kelp Bay follow:

1. The transmitter package was sterilized by storing in a 1:750 solution of Zephiran chloride (Winthrop Div. of Sterling Drug Co., New York, NY).

2. Each otter was immoblized while in the holding cage with an

intramuscular injection of Ketaset and Rompun.

3. After the immobilizing drugs took effect, the otter was removed from the cage and placed on a table in a cabin at the field camp. The incision site was located and thoroughly washed with a disinfectant. The incision for each otter was on the left side, between the hind leg and the ribs. Unlike others who reported implanting procedures, we did not shave the hair from the incision site. We believed leaving the hair would reduce the chance for hypothermia when the animal was released. A fine-pointed scapel blade was used to carefully part the hair where the incision would be made. A sterile surgical drape was then placed over the otter.

4. The incision was made along the parted hairline with a pointed scapel blade, using an upward cutting motion to prevent hair from entering the incision. This incision through the skin, 40 to 50 mm in length, exposed the abdominal muscles. An opening through each muscle layer and peritoneum allowed access to the abdominal cavity. When these openings were of sufficient size, the transmitter package was pushed into the abdominal cavity. Each muscle layer and the skin was then sutured.

5. During surgery 1 to 2 ml of penicillin was administered to each otter.

6. After the surgery each otter was placed in a small holding cage and kept in a warm room until fully ambulatory. The otters were then provided with fish and water. The first two otters were kept in the holding cage and observed for several days after surgery before being released near the capture locations. When no post-operative complications developed among these first otters, the holding period was shortened and subsequent otters were released several hours after surgery.

Radio locating

The primary method of locating the radio-equipped otters was with a hand-held "H" antenna, headphones and a portable radio-telemetry receiver [Telonics Model TR-2 or AVM (Dublin, CA) Model LA-12] from a fiberglass skiff. Resistor-type spark plugs in the outboard engine allowed interference-free reception with the telemetry receiver while the engine was running.

The otters were located by telemetry techniques similar to those described by Mech (1974) and Cochran (1980): homing in on the signal generated by the transmitter and traveling towards the signal with the boat. An estimate of how far inland the otter was from the shore was obtained by continuously monitoring the signal as the boat moved past a radio-equipped otter. Frequent visual observations [376 (19%) at 1979 radio-locations] of the otter being located tended to confirm the accuracy that could be expected during these locating procedures. Information recorded when a radio-equipped otter was located included:

where located, date, time, habitat, activity, number observed, weather and miscellaneous observations. Radio-equipped otters were considered together during a radio-location if they were within 50 m of each other.

Attempts were made to locate radio-equipped otters each day during the study, but these efforts were sometimes prevented because of adverse weather. Multiple locations per day for an individual otter were common, but were not recorded as separate radio-locations unless at least one hour had lapsed between radio-locations. Because of the constraints imposed by weather, changing day length and the distribution of the radio-equipped otters along the shore, timing of radio-locations was, by necessity, not randomly determined.

The site of a natal den was determined by following the transmitter signal to the denning area after the female had localized at a specific site in May. Once the exact area of each female's natal den was determined, I avoided approaching the den areas to minimize disturbance to the female. Radio signals received while listening from the boat verified when the female was in the vicinity of the natal den.

The position of dens for females Nos. 79 and 81 made radio-locations from the boat practical, but the den for female No. 78 was in a drainage with several hills between the ocean shore and the den site. From the boat, it was possible only to determine that No. 78 was between the den and the ocean shore. Probable time of parturition was estimated as a span of 4 days beginning with the date a female first localized in the den area.

Home Range, Movements and Activity Patterns

Home range was defined as the length of coastal shoreline used by a family group or individual otter. Seasonal home range lengths used by the radio-equipped otters were determined by measuring the distance along the shore between the further-most radio-locations. These further-most locations (or end-points of the shoreline home range length) for individual otters were specific sites where a radio-equipped otter was located at least twice during a particular season or for the entire time monitored, similar to the method used by Melquist and Hornocker (1983). Seasonal home range lengths for a family group were determined on the basis of the further-most site of two different radio-locations of any combination of family group members. The shoreline length between single radio-locations beyond the sites used to establish home range length was also measured. Locations were plotted on a 63 mm = 1 km aerial photograph and shoreline length measured using a calibrated map wheel.

Seasons were defined as: spring (March - May), summer (June - August), fall (September - November), and winter (December - February). These seasons were selected to conform to other reports on otter ecology (Larsen 1983, Melquist and Hornocker 1983) and not on the basis of any true seasonality or physiological or behavioral changes that might be exhibited by otter.

Distance moved between radio-locations was used as an indication of otter activity. Movements for individual radio-equipped otters were assessed by measuring on a map the straight-line distance between radio-locations within the same day and between consecutive days. As the otters were frequently located at different sites on those days with multiple locations, one location per day was randomly selected and used for the measurement of consecutive-day movements. Changes of less than 100 m between consecutive-day or same-day locations were recorded as 0.0 km. Seasonal movements of the same otter and between different otters were compared using t-tests (Zar 1974, Johnson 1980) at the 0.05 significance level.

"Monitoring periods" were those in which constant radio contact with an individual otter was maintained for a minimum of one hour. The radio-location information previously described was recorded only for the beginning of a monitoring period. The procedure consisted of locating the otter with the telemetry equipment, then remaining in the area, in the boat or on shore. If the otter moved from the site, it was followed with the boat. Various activities exhibited by the otter during these movements were recorded as well as the distance of any movements.

Activity classifications when otters were located considered whether the otter was in the water or on land, and its behavior. Behavior included: Foraging-feeding, traveling, unknown and other. Behaviors recorded as "other" were known, but occurred infrequently or were not easily included in separate classes. Activity at the time of location was described as a combination of the classifications, such as; in water/foraging-feeding or, on land/unknown.

Specific activity was often indicated by the transmitter signal received while approaching an instrumented otter. Because of the attenuation of the radio signal caused by the salt water, intermittent signal pulses were received from otters diving and surfacing while steady, uninterrupted signals were received from otters on land or remaining at the surface. As the otters dove during feeding and traveling, steady signals almost always indicated the otter was on land. With experience, the signal from an otter foraging (long dives with short periods at the surface) could be distinquished from an otter traveling in water (short dives with longer periods at the surface). The signal from a otter traveling on land, could be distinquished from one at rest on land by the variations in signal intensity and change in the area from which the signal was originating.

While an otter was being located, it was common to receive the signal of an otter that was foraging in the water, but at the approach of the boat, the otter would leave the water and remain on shore while the boat was in the area. When located, the otter's activity was recorded as: "in water/foraging-feeding." When an otter was located on shore, and the signal from the transmitter did not indicate that the otter was traveling, the otter's activity was recorded as: "on land/unknown."

Habitat Use

Information on the otter's use of habitat was collected during each radio-location and included: 1) Distance inland from shoreline (that line of terrestrial vegetation beginning at or above the high water mark), 2) forest (that area inland from the shoreline) characteristics and 3) shore characteristics for those locations within 30 m of the shoreline. The term "site" is used to describe an area where one or more otters were located using the telemetry equipment. Use areas were sites used at least three times by individuals or any combination of members of a family group.

Only one radio-location each day for each radio-equipped otter or group of otters was used for habitat use determination. In the event of multiple locations on a single day, one radio-location was randomly selected.

The classifications for the distance of the otter from shore when located and distance from shore of sites used by the radio-equipped otters are listed in Appendix D. These distances were estimated using the locating procedures from the boat described earlier. Distances for most of the inland locations (such as the natal den areas) were determined by following the signal to the site occupied by the otter and plotting the location on a map or aerial photo.

The classifications for the forest characteristics, which include vegetation type and species, are listed in Appendix D. Uneven-aged old-growth forest (Schoen et al. 1981, Matthews and McKnight 1982) were stands previously not harvested or disturbed except for occasional handlogging early in the century. Leave-strips were areas of uneven-aged old-growth mature timber left standing adjacent to clear cuts. These occurred as narrow bands along the shore and streams or as small inland stands between clear cut areas. Clear cuts were areas where uneven-aged old-growth had been harvested during 1976 and 1977 (See Fig. 2). Conifer regrowth areas of even-aged trees were the result of some disturbance (clearing, timber harvest, wind throw, etc.) and occurred in only a few places in the study area. Muskegs were poorly drained flat areas, common at the higher elevations but also occurring lower down in the forest. These were usually openings in the forest with small pools of standing water surrounded by grasses and sedges. Tidal flats were broad, low relief areas between the salt water and timber, usually inundated during the highest tides. The flats were characterized by small tidal streams, pools, mud and sand with much of it covered by grasses and sedges. These flats occurred at the head of bays or bights and were usually the result of sediment deposition from rivers and streams.

The predominant tree species was listed in each of the vegetation types. In the event of almost equal occurrence of species, both were listed, such as: hemlock/spruce. Stands of mixed conifer/deciduous trees occurred mainly in the flood plains of Glacial and Clear Rivers. A combination of each of the forest characteristics (Appendix D) was used to describe each site, such as: mature conifer forest consisting of hemlock/spruce.

Each site determined to be a "use area" (i.e. three or more radio-locations) was examined. Classifications for the habitat characteristics for each use area are listed in Appendix E. In addition to the above forest characteristics, I estimated and recorded, percent crown closure and shore configuration, as well as the predominant tree height and crown diameter. General features of the area such as presence of burrows, scats and size of the area were also noted.

The classifications of the characteristics of the shore adjacent (perpendicular) to the site where a radio-equipped otter was located are listed in Appendix F. Characteristics included the configuration or shape of the shoreline, the slope and shore material. Information about the shore was recorded only if the radio-equipped otter was on land and within 30 m of shore. For those radio-locations where an otter was inland greater than 30 m, I could not assume that the shore perpendicular to the inland site of the otter's location was where the otter left the water. Shore classifications were noted when the otters were in the water, but not used in the analysis of habitat since the otters usually were moving and not associated with a particular kind of shore.

Shore slope was the vertical angle (in degrees from horizontal) between the level of the water at the highest tides (at the forest edge) and the level of the water at a low tide. The slope was determined with a clinometer or by estimation. Shores were grouped into the classes listed in Appendix F. Areas of inconsistent slope were included in the class, "variable". Shore material was classified according to the predominant type listed in Appendix F. Areas with no predominant type of shore material were recorded as "mixed". An area of shore was described as a combination of particular slope and material classes, such as; 21 to 40^{o}/large rock.

During low tides, the entire home range of each of the four family groups was mapped for the shore slope and material. Such mapping allowed determination of the availability of each shore classification. To test the hypothesis that otters utilized shores according to availability, chi-square goodness of fit analysis and Bonferroni z-statistic (Neu et al. 1974) were used.

Habitat characteristics for the natal den areas were determined when the adult females were radio-tracked to the den areas. Forest characteristics and use area information as described earlier were recorded as well as elevation and distance to fresh water.

One otter, adult male No. 76M, died shortly after the surgery to implant the radio-transmitter. Information recorded for this otter was not used in the analysis of habitat use or home range, movements and activity.

PHYSICAL CHARACTERISTICS, DEMOGRAPHY AND FAMILY GROUP INFORMATION

Introduction

River otters are medium sized animals weighing 5 to 16 kg and measuring 900 to 1400 mm total length. They are characterized by low compact bodies, dark brown fur, with a yellowish to gray brown patch from chin to chest, short front legs set well back from the neck and large, powerful hind legs with webbed hind feet. Body shape appears to taper gradually from the nose to the hips, with a large slightly dorsoventrally flattened, tapering tail, which can be almost one-third the entire length of the otter.

Features not so easily noticed are the small (2 to 3 mm) round rugosities on the bottom of the pads of the feet (which probably aid in walking on smooth rock or ice), a short, blunt claw at the end of each toe, well developed vibrissae on each side of the face, and small gray to bluish eyes.

Numerous aspects of river otter behavior and life-history are not well understood. Until recently, most information has come from observations of otters raised in captivity (Liers 1951, Wayre 1976). Records of weights and other body measurements have been compiled from areas where otters are abundant enough to be trapped for fur.

The reproductive biology of river otters in the wild is another facet of otter ecology that is largely unknown. Studies of reproductive tracts from trapped otters (Hamilton and Eadie 1964, Tabor and Wight 1977) have provided some information, but on a limited scale.

The objectives for this part of the study were:

1. To determine the physical measurements of river otters in Kelp Bay.

2. To determine the reproductive performance, family group dynamics and population characteristics of river otters in Kelp Bay.

Results and Discussion

Captures

Fifteen river otters were captured during four trapping sessions in 1982: February 11-April 9, April 23-26, June 29-August 24 and October 3-9. Trapping was discontinued from April 26 to June 29 to prevent capturing female otters that were near term or with newborn pups. Thirteen otters were captured in Hancock traps and two in leg-hold traps. Leg-hold traps were used only during the first trapping period. Success rates for Hancock traps and all leg-hold traps were 1 otter per 58 and 137 trapnights, respectively (Table 1). Otters escaped from traps on 19 known occasions and four non-target animals (three mink and one adult bald eagle) were captured and released. Traps were found snapped or closed on 34 occasions when I

TABLE 1. Results of live-trapping for river otter at Kelp Bay, Alaska.

	Trapping sessions							
	Feb. 11 to April 9				April 23-27	June 28 to Aug. 24	Oct. 3-9	Total
Trap type[a]	H	3	4	48	H	H	H	
Trap nights	324	126	85	27	7	398	25	992
Otter captures	4	0	1	1	1	6	2	15
Otter escapes	3	7	8	0	0	1	0	19
Traps snapped[b]	9	0	1	0	1	19	4	34
Non-target	1[c]	2[d]	0	1[d]	0	0	0	4

[a]Trap type, H = Hancock, 3 = No. 3 Newhouse, 4 = No. 4 Victor, 48 = No. 48 Newhouse
[b]Reason unknown
[c]Adult bald eagle
[d]Mink

could not ascertain the cause.

Of the 15 otters captured (Table 2), four were adult females, three were adult males, three were male pups (3.5, 5.5 and 10 months), three were female pups (3.5, 3.5 and 5.5 months), and two were pups of unidentified sex appproximately three months old. The two pups of unknown sex were released without handling at the capture site because of their small size. Several weeks after those two pups were released, two of the pups that were later equipped with radio-transmitters were captured together, at the same location as the previous two pups.

A total of 1979 radio-locations was recorded for the twelve otters that were instrumented (Table 2), of which 376 (19%) included visual observations. The number of radio-locations per individual otter ranged from 6 to 502. The length of time individual otters were monitored ranged from 8 to 304 days and otters were located on 259 days.

Physical Characteristics

Weights and Measurements

Measurements from captured otter included weight, total length, tail length, hind foot length, and upper and lower canine length (Table 2). Four adult females (Nos. 71, 78, 79 and 81) were measured (weights: 10 to 14 kg and total lengths: 1230 to 1325 mm). All of these, except No. 71, were noticeably pregnant at the time of capture. The weight of the heaviest female (No. 78) was probably a reflection

TABLE 2. Summary of data for river otters captured at Kelp Bay, Alaska.

	Otter number												
	99	76M	78	97	71	91	581	81	70	76	95	79	74
Capture date	3/3	4/1	4/24	10/8	8/7	10/8	2/22	3/27	8/16	8/19	8/19	3/31	4/8
Sex	M	M	F	M	F	F	M	F	F	F	M	F	M
Age	10 mo.	Ad.	Ad.	5.5 mo.	Ad.	5.5 mo.	Ad.	Ad.	3.5 mo.	3.5 mo.	3.5 mo.	Ad.	Ad.
Weight (kg)	8.4	8.6	14.0	5.9	10.0	6.8	11.5	12.2	3.6	3.6	4.0	10.4	15.0[b]
Tot. length (mm)	1257	1330	1300	1060	1230	1065	1308	1325	890	830	880	1245	1370
Tail length (mm)	457	470	-	390	440	420	508	500	320	310	330	450	460
H. foot (mm)	146	150	-	140	140	140	126	145	120	120	130	130	135
Upper canine (mm)	-	9	-	13	14	-[a]	-	-	10	9	9	8	-
Lower canine (mm)	-	8	-	11	10	8	-	-	9	8	8	4	-
No. of radio-locations	502	6	311	38	128	57	-	286	105	107	103	244	92
Visual obs.	101	1	77	11	32	25	-	28	30	25	24	6	19
No. of days located	241	3	177	18	92	43	-	195	77	80	76	180	83
Length of tracking period (days)	304	8	251	36	149	85	-	280	138	135	135	276	288

[a] Upper left canine broken.
[b] Exceeded 15 kg limit on scales.

of being within 11 to 14 days of parturition.

The adult males captured (Nos. 76M, 581 and 74) exhibited a broad range of weights (8.6 to greater than 15 kg) although the total lengths were similar. Male No. 76M appeared to be in an extremely emaciated condition upon capture.

Six juvenile otters (less than 12 months) were captured during three different seasons. Three were trapped between August 16 and 19; females Nos. 70 and 76 and male No. 95. Number 70 was captured three days before No. 76 and had greater total body length though they weighed the same. Male No. 95 was the heaviest of the three, though his total length was between that of the female pups. Otter pups Nos. 76 and 95 were captured together in the same trap, near No. 70's capture location and they were all part of the same family group (See Demography, page 37). Female pup No. 91 and male pup No. 97 were captured on the same day (October 8) in different areas of Kelp Bay. They had approximately the same total lengths, but the female was heavier.

Male No. 99 with a total length of 1275 mm, was similar in length to the group of adult females, yet he weighed only 8.4 kg. The unworn condition of his teeth and his weight at capture (March 3) indicated he was probably a juvenile. The permanent canine teeth of the juveniles captured in August were incompletely emerged while those captured in October and March exhibited complete eruption.

Melquist and Hornocker (1983) indicated that pups grow rapidly during their first 10 months, but there is probably a great deal of individual variation. The number of juveniles measured was not sufficient nor were the dates of capture spaced out evenly enough to determine their rate of growth in Kelp Bay.

Total length and weight measurements for adult otters captured at Kelp Bay (1230 to 1370 mm and 8.6 to 15 kg) tended to be at the maximum end or exceed the range of measurements for river otters given by Hall and Kelson (1959) and Hall (1981): 889 to 1300 mm and 5 to 10 kg. Comparisons of measurements of otters from other geographic regions (Table 3) indicate that the otters in southeastern Alaska are one of the larger forms. Measurements of otters from Baranof and Chichagof Islands and the Wrangell area support this (unpublished file data from ADFG, Game Division, Sitka).

Because of the small number of adult otters of both sexes and the varied reproductive status of the females (and the effect this might have had on body weights), no statistical comparison of body measurements were made between sexes in Kelp Bay or to other studies.

Demography

Reproduction

In a review of the literature on river otters, Johnson (1981) stated that the reproductive biology is not well understood. The information that is available comes from both captive and wild otters and is at times conflicting. Otters and some other mustelids (Hamlett 1935, Wright 1942, and Hamilton and Eadie 1964) exhibit a reproductive

TABLE 3. Body measurements of river otters from different geographic areas. Either whole body or skinned carcass measurements are presented.

	MALES						FEMALES						
	Weight (kg)			Length (mm)			Weight (kg)			Length (mm)			
	Range	Mean	N	Range	Mean	N	Range	Mean	N	Range	Mean	N	
Kelp Bay[a]	8.6 - 15.0	11.7	3	1303 - 1370	1336	3	10.0 - 14.0	11.7	4	1230 - 1345	1275	4	Present study
Prince of Wales Island[b]	9.5 - 11.8	10.7	2	-	-	-	7.7 - 11.8[c]	9.1	4	-	-	-	Larsen 1983
Southeast Alaska[b,c]	2.3 - 13.8	8.3	84	975 - 1383	1193	82	2.5 - 12.3	7.4	64	991 - 1380	1166	64	ADFG[d]
Alberta, Canada[a]	9.0 - 11.4	10.5	5	1165 - 1294	1238	5	7.5 - 8.1	7.8	3	1135 - 1222	1181	3	Reid 1983
Texas[a]	< 9.1	-	3	-	-	-	< 9.7	-	5	-	-	-	Foy 1982
W. central Idaho[a]	-	9.2	4	1150 - 1201	1177	4	-	7.9	6	1070 - 1132	1111	6	Melquist and Hornocker 1983
Ontario, Canada[e]	-	5.8	140	-	1096	134	-	4.6	117	-	1045	116	Stephenson 1977

[a]Adults only.
[b]All age classes.
[c]Included skinned carcass weights. Stephenson (1977) reported skinned carcass weights of males and females averaged 81.0% and 80.4% of whole body weights, respectively.
[d]Unpublished data from ADFG, Game Division, Sitka, Alaska.
[e]Mean of average weight and length for each age class older than 1 year.

strategy termed "delayed implantation". After breeding and fertilization occurs, the zygote remains in the female reproductive tract as an unimplanted blastocyst. At a later date implantation of the blastocyst on the uterine wall occurs, after which fetal development proceeds until parturition. Usual litter size has been reported as two or three pups (Harris 1968, Melquist and Hornocker 1983). Liers (1951) and Hamilton and Eadie (1958) indicated that breeding occurs soon after parturition. Liers further reported that the period of the female's receptivity could be as long as 42 days and that the male and female may mate several times during that period.

Three adult females (Nos. 78, 79 and 81) captured in spring 1982 were determined to be pregnant at the time of capture. The minimum number of fetuses each otter was carrying was determined by external palpation. The probable parturition dates indicate all three gave birth in early May 1982.

Adult female otter No. 78, the heaviest of the female otters, was captured April 24. Her teeth were not as worn as those of the other adult females. At the time of capture it was very apparent that she was pregnant. Mammary and teat development was pronounced and at least one fetus was discernible. She localized at the natal area between May 6 and 9 and continued to return and use that area until July 19. On August 25 she was observed with two pups. In May, 1983, No. 78 again localized at the 1982 denning area.

Adult female No. 79, captured March 31, appeared to be older than the other adult females. Her canine teeth were worn and her lower incisors were worn almost to the gumline. At least one fetus was felt at the time of implanting the radio transmitter. This otter localized in the area later suspected to be her natal den between May 6 and 9. She no longer returned to the den area after June 6. This female was not observed with pups during 1982, nor were pups observed in the area that could be considered her home range.

Adult female No. 79 probably gave birth, although no pups were observed with her in summer or fall 1982. Evidence that she gave birth includes the following: She was pregnant at the time of capture, she moved to an inland denning area at approximately the same time as Nos. 78 and 81, and she was observed breeding shortly after localizing at the inland den area. Number 79 was seldom observed throughout the study. This probably contributed to the failure to observe any pups she might have had. She was sighted on only 5 occasions at 244 radio-locations as compared to 79 visual observation at 311 radio-locations for No. 78, and 26 sightings of No. 81 at 286 radio-locations.

Female No. 81, captured March 27, did not appear to be an exceptionally old adult from the amount of wear on her teeth. At least two fetuses were felt during handling. Between May 3 and 6 she localized in the inland area that was later determined to be her denning location. She continued to return to this area until July 16, though she was occasionally located along the shore. Juvenile otters were first observed in the area used by No. 81 on July 30, but she was not actually located with pups until August 6. After that date she was frequently located with up to 4 pups and several adult-sized otters.

Female No. 71 was captured on August 7, later in the year than the other adult females. When captured, the enlarged and darkened conditions of two of her four teats indicated that she had nursed pups during that summer. The first time pups were observed near her was on August 18. Later during the summer, she was occasionally observed with two pups, one of which, female No. 91, was captured and radioed. In May, 1983 No. 71 was located in the area determined to be her denning area.

No published accounts documenting the breeding season of river otters in southeastern Alaska are available and few exist for wild otters from other areas (Sheffer 1967, Melquist and Hornocker 1983). Otters were observed breeding in the Kelp Bay area on six occasions during 1982 (Table 4). The first observation occurred May 9, on a small island near Crow Island in the Basin (Fig. 1). This area was not within the home range of any of the radio-equipped otters. A detailed account of that first observation of mating follows:

Time 2100: While sitting in the boat near a small island I heard a high-pitched "cackling-like" otter vocalization [described as "caterwauling" by Liers (1951)]. The sound came from on land, away from the shore and appeared to be moving toward the shore.

Time 2114: Two adult-sized otters came out of the forest moving toward the shore. The larger otter (apparently the male) was attempting to mount the smaller otter (apparently the female) while holding

TABLE 4. Observations of river otters mating on Baranof Island, Alaska.

Date	Time	Location	Comments	Observer
May 9, 1982	2100	Kelp Bay	unradioed otter	Woolington[a]
May 14, 1982	1215	Kelp Bay	No. 79	Bovee[a]
May 15, 1982	2200	Kelp Bay	near No. 81[b]	Woolington[a]
May 16, 1982	2022	Kelp Bay	probably No. 78[c]	Woolington[a]
May 16, 1982	1930	Kasnyku Bay,	unradioed otter	Bovee[a]
May 18, 1982	0550	Kelp Bay	No. 78	Bovee[a]
May 31, 1982	0720	Kelp Bay	No. 78	Woolington[a]
May 1981	unk.	Kasnyku Bay	unradioed otter	Smith[d]
May 17, 1983	unk.	Silver Bay,	unradioed otter	Johnson[e]

[a]Present study personnel
[b]Possible mating activity, unable to confirm because of darkness, definitely not adult Female No. 81.
[c]See text p. 41
[d]K. Smith, ADFG, Hidden Falls Hatchery, FRED Division.
[e]B. Johnson, ADFG, Sitka, Sport Fish Division.

onto the back of her neck with his teeth. The female continued to make the loud vocalizations that I had heard as they moved to the shore. They left the forest and crossed the 41° to 60°/solid bedrock shore and entered the water. Between the time they left the forest and entered the water, the male would alternately straddle the female's back or walk along side her. All during this time he continued his hold onto the back of her neck. It did not appear that copulation was actually occurring at this time. Upon reaching and entering the water, both otters rolled over several times and occasionally both were completely submerged. The smaller otter was still being held by the back of the neck.

Time 2132: The otters parted, one left the water and ran briefly along the shore, then re-entered the water. The otter that had remained in the water followed after the other. Several times when they were close to each other, they faced each other, raised their forequarters out of the water, then entered the water in a porpoise-like manner.

Time 2138: The larger of the two otters left the other and swam toward nearby Crow Island. The smaller otter left the water and disappeared from view on the small island.

When copulation occurred could not be determined, but the activity described above is similar to those few observations available from captive otters (Liers 1951, Wayre 1976). The other observations of mating behavior made during this study were similar to the account described above: the behavior took place on land and in water, and was accompanied by frequent or constant vocalization.

Adult female No. 78 was observed mating on two occasions (May 18 and 31) and possibly a third (May 16). On May 16 three otters were observed near a rocky point within the home range of No. 78 and No. 99 (a one-year old male at this time and frequently located with No. 78). The two largest of the otters were observed mating. The telemetry receiver was not available to confirm that this might have been No. 78 until one hour later, when Nos. 78 and 99 were located 0.3 km from where the otters had been observed mating. Further evidence supporting my belief that No. 78 had indeed been one of the otters observed mating was that from May though November, no otters, other than those that could be accounted for by radio-telemetry, were observed in this area (278 locations for No. 78 and 380 locations for No. 99 during that period).

Liers (1951) reported captive otters in Minnesota giving birth from November through mid-January with the length of time between breeding and parturition ranging from 9 months 18 days to 12 months 15 days. Johnson (1981) observed that lactating females or those with developing embryos were not taken during the winter trapping season in southeastern Alaska and suggested that Liers' winter whelping dates may have been influenced by captivity. Melquist and Hornocker (1983) gave parturition dates for otter in west central Idaho as March or April, which agrees with data presented by Tabor and Wight (1977) in Oregon.

In New York, Hamilton and Eadie (1964) found no evidence of developing fetuses until mid-February, which would tend to agree with the parturition dates in Idaho.

In Texas, Foy (1982) observed three young wild pups with an estimated date of birth between January 22 and February 4, and captured two pregnant females between December 8 and February 10. The data presented for Kelp Bay indicate that otters gave birth and bred later than was reported for otters in any of the published reports.

Observations from Kelp Bay, of two radio-equipped females known to have denned (Nos. 78 and 79), support Hamilton and Eadie's (1964) contention that otters mate soon after parturition. Their conclusion was based on data from reproductive tracts of otters obtained from trappers. Circumstantial evidence from Kelp Bay, which provides further support for breeding soon after parturition, includes the observations of otters not equipped with radio transmitters mating in May, female No. 81's parturition date between May 3 and 7 and another litter (No. 71's) of pups of comparable size to juveniles known born in May.

Population characteristics

An estimate of the number of river otters in Kelp Bay was made for the area used by the radioed family groups. This estimate was based on the known minimum number of otters within the shoreline used by all the family groups (home range lengths) and is expressed as the minimum number of otters per kilometer of shoreline. A minimum of 18 otters used a total of 21.4 km (1 otter per 1.18 km) of marine shore. No otters, other than those which could be accounted for as members of the radio-equipped family groups, were observed within the family group home ranges, despite many hours of observation.

Melquist and Hornocker (1983) in west central Idaho and Larsen (1983) on Prince of Wales Island in southeast Alaska also determined otter density on the basis of shoreline. A comparison of Kelp Bay (1 otter per 1.18 km of shore) with the Prince of Wales Island study (1 otter per 1.9 to 2.1 km) reveals that otters may have been more abundant per unit of shore in Kelp Bay. Melquist and Hornocker (1983) reported 1 otter per 3.7 km of waterway, though the marine and freshwater shorelines probably are not directly comparable. They also reported a density of breeding females of 1 female per 20 km of waterway whereas in Kelp Bay this estimate would be 1 female per 5.75 km of shoreline. Again, caution should be exercised when comparing data from marine and freshwater systems.

The radio-equipped otter pups were frequently separated from the adult females during radio-locations beginning in November, but remained within their formerly used areas until fieldwork terminated in early January 1983. Melquist and Hornocker (1983) reported that otters in west central Idaho started dispersing at 12 to 13 months of age. During this study, only one yearling, male No. 99, was equipped with a radio transmitter. He remained within the area used by his family group until the end of December, 1982. In early January 1983, when he was approximately 20 months old, No. 99 was located outside of his home range and appeared to be in the process of dispersing. Unfortunately at this time radio-tracking activities were terminated.

Mortality

The extent of mortality in an otter population, whether natural or a result of man's activities, is another facet of otter ecology that is poorly understood. There are probably few natural enemies of otters in southeastern Alaska. The only larger carnivore on Baranof Island, brown bears, could kill otters, but I am not aware of reports of interactions between otters and brown bears. Adult bald eagles may be large enough to take an occasional otter pup, but again this is only speculation. Rosen (1975) reported an eagle and an otter both dying, apparently the result of a conflict over a fish. On numerous occasions during the Kelp Bay study, eagles were spotted close to swimming otters, but no interactions were observed. Several areas actively used by otters were also sites of active eagle nests. Larsen (1983) suggested that killer whales may on occasion take river otters in coastal areas.

Three of the captured otters died. Adult male No. 581 died soon after being captured and placed in the holding pen. A heavy storm prevented checking the traps the day before the otter was removed from the Hancock trap and it is possible that he had been in the trap overnight. Death may have been caused by the immobilization drugs and the low air temperature (-9°C) while the otter was transported in the open boat to the field camp. Fowler (1978) attributed the death of a roloway monkey (Cercopithecus diana roloway) to hypothermia after immobilization with ketamine hydrochloride. The immoblizing drug has the effect of impairing the central nervous system's thermoregulatory ability.

Adult male No. 76M died approximately six days after surgery. At the time of capture this otter appeared extremely emaciated, with ribs and other bones easily felt. All of No. 76M's canines were worn to the gumline. After this otter was released, he traveled approximately 3.2 km (straight-line distance) to the area where he was later found dead. A field necropsy showed that the incision for the surgery had begun to heal at all tissue layers and there was no evidence of inflammation in the abdominal cavity. An unidentified gelatinous mass (approximately 6 x 5 cm) was found on one part of the otter's liver. External body measurements for 76M were approximately the same as for adult male No. 74 (which weighed greater than 15 kg), but body weight for No. 76M at the time of surgery and death was approximatley 8.6 kg. Little body or omental fat was found on No. 76M during the examination.

Male pup No. 97 died approximately 26 to 37 days after release. The exact date of death was not determined because project personnel were absent from the study area during this 11-day period. That otter appeared in good condition when released and traveled freely with its family group until early November. After repeatedly locating this otter at the same site for several days with no indication of movement, the burrow system from where the signal was originating was entered.

The dead otter was found on a moss bed in a small chamber off the main chamber of the burrow system. Number 97 was removed from the burrow and sent to Sitka where a necropsy was performed by Dr. Bauder. He reported finding no lesions, infections or other abnormalities that may have been caused by the surgery to implant the transmitter. He did observe fluid in the lungs, but whether this was related to the ultimate cause of death is unknown.

Melquist and Hornocker (1983) reported the death of several otters during their study, but in most instances the remains were found with the aid of radio-telemetry equipment and they felt it was not common to find the remains of an otter dying from natural causes. Employees of the USFS, Sitka Ranger District, reported the remains of an otter several kilometers upstream from the mouth of a river (S. Buchanan, pers. comm.). The cause of death for this unusual find was not determined.

The natural life span of otters appears to be relatively long. Ages of wild caught otters have been reported as high as 11 and 13 years (Stephenson 1977, Tabor and Wight 1977) and captive animals have lived to the age of 16 years (Liers 1951).

Numerous otters are taken in Alaska during the fur trapping season (December 1 to February 15) in Game Management Unit 4, which includes Admiralty, Baranof, Chichagof and adjacent islands. There is no harvest limit on the number of otters a licensed trapper can take.

Since 1977 regulations of the ADFG have required otter skins to be tagged by a representative of the State and information collected on date and location of kill, method of take, sex and measurements (stretched hide length and width) within 30 days of the close of the trapping season. These sealing records from ADFG indicate that between 1977 and 1983 an average of 2082 (range 1573 to 2382) otters have been taken statewide. Game Management Unit 4 has averaged 167 per year (range 153 to 184) (ADFG, unpublished file data).

Few otters were known to have been trapped or shot by hunters in Kelp Bay during the last several years. Aside from those few known taken by trappers or the three study animals previously mentioned, the only other known otter mortality in Kelp Bay was reported by a commercial crab fisherman. An adult-sized male otter was found drowned in a crab pot set at a depth of approximately 10 m. Scheffer (1953) also reported otters drowning in crab pots near Baranof Island. It is not known how often this might occur.

In the absence of any serious large predator species or trapping, it is unknown what causes of mortality might occur in an otter population or what population control mechanisms might come into play.

Family groups

Most available information concerning the composition and characteristics of family groups of otters has come from studies of captive otters (Liers 1951, Crandall 1966 and Wayre 1976). Recent field studies of free-ranging river otters in the wild (Foy 1982, Reid 1982, 1983, Larsen 1983, Melquist and Hornocker 1983) have provided data on family group characteristics as well as habitat use, home range and movements by using radio-telemetry.

Ten radio-equipped river otters in Kelp Bay were in four family groups that used adjacent, but essentially non-overlapping, home ranges. A typical family group consisted of an adult female, other adult-sized otters and young-of-the-year. In most cases, the age or sex of the other adult-sized otters could not be determined. In only one family group of five (No. 78's) was the age and sex known of one of the larger otters (i.e. male No. 99) other than the adult female. Number 99 was captured when 10 months old, remained in the area used by No. 78, and was located with her at 189 of 502 radio-locations. The familial relationship between Nos. 78 and 99 was not known, but possibly he was one of No. 78's pups from 1981. Another family group consisted of two radio-equipped otters (adult female No. 71 and female pup No. 91), an adult-sized otter of unknown age and sex, and a pup of unknown sex. The third group included adult female No. 81, female pups Nos. 70 and 76, male pup No. 95, and a pup and two adult-sized otter of unknown age and sex.

The total size of the group of otters that was affiliated with adult female No. 79 is unknown. As stated earlier, the number of pups that No. 79 may have had in spring 1982 could not be determined. One adult-sized otter was observed with or near her occasionally.

Throughout the denning season, early May through mid-July, Nos. 78, 79 and 81 returned to the natal den areas. (See Habitat Use: Natal den areas). The latest that any of these females returned to the den areas was July 19. After that date, the radio-equipped otters localized at specific areas along the shore. Pups were observed traveling with the radio-equipped adult females as early as August 6. After the pups appeared to be mobile, none of these family groups returned to the initially used shoreline sites for extended stays. From August to mid-November the pups were consistently located with the adult females.

I considered a family group of otters to consist of an adult female, pups of the year, and some other otters of various ages and sexes. Melquist and Hornocker (1983) used this same concept, although they were able to confirm the presence of a second radio-equipped adult female in one group. In Kelp Bay, the presence of more than one adult female in a family group could only be suspected. In the family groups studied, there were adult-sized otters in addition to the radio-equipped females, but I could not determine their age or sex with the exception of male No. 99. Possibly these others were pups from previous years or non related adult females. If there were several adult females in the group, the pups could have been from different litters. For example, the group with adult female No. 81 consisted of three adult-sized otters and four pups.

The role of the adult male otter in family groups is not well documented. Only one radio-equipped adult male (No. 74) was followed for a substantial length of time, but he was not in the area used by the radio-equipped family groups. On three occasions he was observed traveling and feeding with four unradioed adult-sized otters, all of comparable size. The sex and age of the rest of this group was unknown.

Most published accounts indicate that adult male otters do not function as part of family groups with young otters (Liers 1951, Crandall 1966, Melquist and Hornocker 1983). Liers (1951) and Wayre (1976) reported that captive females actively kept the male otters away from young pups. How this might relate to the wild when the pups are mobile and traveling with the adult females is unknown. Home (1982) described several family groups of river otters in the Glacier Bay area of southeastern Alaska as actually being led by adult males, although he did not describe how he determined the age or sex of any of the family group members. Groups of "non-breeding adult males" were reported by Solf (1978) although he did not describe how he aged and sexed the entire group. Liers (1951) reported that captive male otters were not sexually mature until at least two years old and that many adult males were never capable of breeding. The effects that captivity might have had on this capability and how it might relate to otters in the wild is unknown.

L. Johnson (pers. comm.) has assembled the following observations by Sitka residents of very large groups of otters from the Baranof Island area: K. Bovee and K. Johnson of Sitka reported a group of at least 12 otters in Surgis Narrows in late November, 1977. M. Johnson observed 9 or 10 otters together in Nakwesina Sound in March 1978 or 1979. Between 11 and 14 otters were observed together in a group by A. Schmidt in October, 1978 on Halleck Island. In all of the reports, the familial associations, sex and age composition or permanence of the group were unknown.

SUMMARY

Fifteen river otters were captured in Kelp Bay and radio-transmitters were surgically implanted in 12. Radio-equipped otters included two adult males, four adult females, three male pups and three female pups. The most successful method of capture involved using Hancock live-traps in trails and runways. Radio-equipped otters were located on 1979 occasions and visually observed at 378 of the radio-locations. The number of radio-locations per otter ranged from 6 to 502.

Physical measurements were recorded for each captured otter. The largest, an adult male, weighed slightly greater than 15 kg with a total body length of 1370 mm. The otters examined at Kelp Bay and additional information on otter body measurements from southeastern Alaska and other areas, indicated river otters in southeastern Alaska may be one of the larger forms of this species.

Three adult females captured in spring 1982 were determined to be pregnant at the time of capture. All three moved to natal den areas in early May and continued to return to those sites after foraging trips along the shore. Soon after moving the pups from the den areas to the shore in June or July, the otters traveled within their respective home ranges as family units. The family groups studied were known to consist of: The radio-equipped adult females, radio-equipped pups of known sex, pups of unknown sex and adult-sized otters of unknown sex or age. One family group contained a radio-equipped yearling male which

was adult sized.

Otters were observed mating on six occasions in May 1982. This information corroborated other reports that otters mate soon after parturition. This study determined the breeding and parturition season of river otters in that part of southeastern Alaska was in May.

HOME RANGE, MOVEMENTS AND ACTIVITY PATTERNS

Introduction

Prior to Larsen's (1983) study of river otters on Prince of Wales Island, information on otter movements or activities in southeastern Alaska was based largely on anecdotal observations. The development of implantable radio-telemetry equipment and procedures has enabled researchers to follow individual otters and determine what areas otters use and the timing and extent of movements and activities (Melquist and Hornocker 1983).

During the development of this project, it was apparent that no consensus existed on the extent of otter movements. Several interesting observations and hypotheses concerning otter activities were discussed. One was that otters seemed to appear at particular sites at regular intervals of several days or weeks, which suggested the otters were traveling in a circuital route, probably covering large areas. Another suggestion was that perhaps otters, in the course of their travels, move long distances between the larger islands in southeastern Alaska. One other suggestion was that otters change home ranges from the shore to inland areas with different seasons. Information collected during this study at Kelp Bay has shed light on some of the above.

Objectives for this section of the study included:

1. To determine the size of home range used by river otters in Kelp Bay.

2. To determine movement and activity patterns of river otters in Kelp Bay.

Results and Discussion

Home range

For this study, home range was considered the length of marine shoreline used by a family group or an individual otter. Melquist and Hornocker (1983) used this concept of linear home range for river otters inhabiting river and lake systems in Idaho, as did Larsen (1983) studying river otters on Prince of Wales Island in southeastern Alaska. Stumf and Mohr (1962) described use of linear home ranges for several species of mammals and birds. I felt the use of shoreline length to describe the home range of otters at Kelp Bay was justified because for 566 (75.4%) of the 751 radio-locations (see Habitat Use) where the otters were located on land, they were no more than 30 m from shore. Locations greater than 30 m inland included natal dens and use of a river system by one otter.

The use of elliptical home range models was considered inappropriate because the otters did not appear to use the area in a bivariate-normal pattern (Smith 1983). Similarly, the polygon method of determining home range size seemed inappropriate because most of the otter home range estimates by that method would have included areas seldom or never used by otters (examples: mountain tops or open bay far from shore).

I was unable to locate specific radio-equipped otters of each of the four family groups during only a few (less than 6) location attempts. Adult male No. 79 was not located during every attempt. This was probably due to his use of river valley bottoms (discussed in: Habitat Use) and the large size of his home range.

Otters appeared to move freely within their respective home ranges, and it was common for an individual to cover the entire length of its home range during one or two days. Length of home range in each season was determined for five of the otters (Table 5). Information for the winter was available for only one month (December). With the exception of adult male No. 74, the home ranges of each of the individuals and family groups remained in the same area of shore in all seasons. The length of the home ranges for these groups expanded or contracted seasonally, but did not involve movement to a different area. Small differences in length may be attributable to the inherent inaccuracy of transferring a located site to a map, then measuring the length of the shoreline on the map.

The number of radio-locations per otter for each season (4 to 206) and the amount of shoreline used each season (1.0 to 22.5 km) varied widely (Table 5). The most marked difference among seasons in length of home range was for adult male No. 74, who used 22.5 km of shoreline

TABLE 5. Number of radio-locations and length of home range (km) for river otters at Kelp Bay, Alaska. Dashed lines separate family groups.

Otter number	Spring	Summer	Fall	Winter	All Seasons[a]
	No. loc./length	No. loc./length	No. loc./length	No. loc./length	No. loc./length
Male 99	155/3.0	207/3.1	118/3.1	22/2.7	502/3.4
Ad. Fem. 78	31/2.2	135/3.0	118/2.9	27/2.1	311/3.2
Male pup 97	-	-	38/2.9	-	38/2.9
Ad. Fem. 71	-	28/3.6	79/4.8	21/2.6	128/5.4
Fem. pup 91	-	-	38/4.5	19/4.1	57/4.8
Ad. Fem. 81	67/4.0	131/5.1	69/7.2	19/6.2	286/9.1
Fem. pup 70	-	13/1.8	73/7.9	19/1.5	105/9.7
Fem. pup 76	-	13/1.8	74/7.9	20/1.2	107/8.4
Male pup 95	-	13/1.8	73/6.8	17/—	103/7.3
Ad. Fem. 79	63/2.3	110/2.3	57/1.2	14/1.0	244/2.9
Ad. Male 74	43/22.5	33/4.8	12/1.0	4/—	92/23.8

[a]"All Seasons" includes all the seasons for which a particular river otter was equipped with a radio-transmitter and available for locating.

during the spring, 4.8 during the summer and only 1.0 km during the fall. Home range length during the winter was not determined for No. 74 because insufficient radio-locations were obtained. For all of the other adult-sized otters, there was no pattern of relationships between seasons and home range length. The pups,as might be expected, increased the amount of shore used from summer to fall.

Home ranges of the four family groups studied were on adjacent sections of shoreline (Fig. 3). Seasonal home range length for each family group is presented in Table 6. A small overlap (approximately 0.5 km) occurred between the home ranges of the family groups with adult females Nos. 78 and 71. This appeared to be a temporal separation, as the two groups or members of the two groups were never located together or near each other in this area. No overlap was observed between the other groups.

Melquist and Hornocker (1983) found that home ranges of family groups commonly overlapped. They raised the possibility that availability of food or cover may have contributed to this overlap. In their study area, runs of spawning fish occurred at specific sites during certain seasons. On several occasions Melquist and Hornocker observed radio-equipped individuals or family groups utilizing those food sources at the same time. Some areas within the home ranges of otters in Idaho did not contain much suitable cover, but the suitable areas were sometimes used by otters not normally associated with each other. Gipson et al. (1982) observed concentrations of otter tracks along the Susitna River in southcentral Alaska in November. They suggested the otters may have localized along the river to feed on

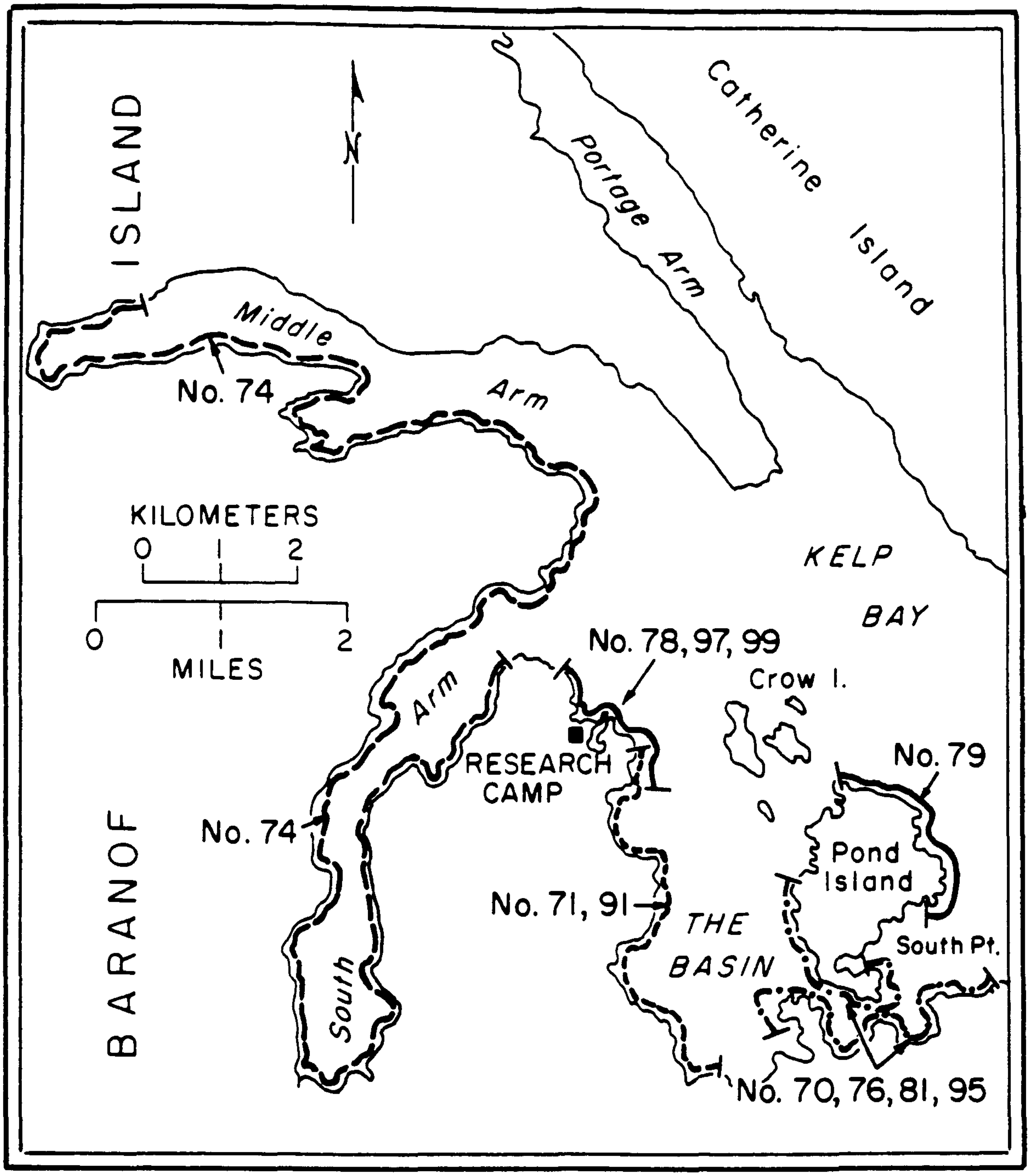

Figure 3. Home range of radio-equipped river otters at Kelp Bay, Alaska.

TABLE 6. Home range length (km) during each season for each radio-equipped river otter family group in Kelp Bay, Alaska. Home range length was length of shoreline used by each family group. Families are grouped according to identification number of the radio-equipped adult female affiliated with each group.

Female	Spring	Summer	Fall	Winter	All Seasons[a]
No. 78	3.0	3.3	3.3	3.0	4.1
No. 71	–[b]	3.6	4.9	5.3	5.4
No. 81	4.0	5.1	7.9	6.2	11.3
No. 79	2.3	2.3	1.2	1.0	2.9

[a]"All Seasons" includes all the seasons for which a particular river otter was equipped with a radio-transmitter and available for locating.
[b]No. 71 was captured in the summer, so there were no radio-locations in the spring.

grayling (Thymallus signifer) which were moving from the tributaries to the Susitna River to overwinter.

Melquist and Hornocker (1983) also found that some otters used different areas in different seasons. At Kelp Bay, adult male No. 74 appeared to utilize different areas. In the spring, he used both Middle and South Arms, but during summer and most of the fall, radio-locations indicated that he used mostly the south end of South Arm, when salmon were spawning in Clear and Glacial Rivers.

Occasionally, individuals or family group were located at sites beyond the shoreline sites that were used in determining home range lengths. These sites did not meet the criteria of two locations of an individual or combination of family group members. With the exception of the sites occurring within the overlap between No. 78's and No. 71's group home ranges, these areas were infrequently visited by adjacent family groups. How these infrequently visited areas between the home ranges might be involved in resource partitioning is unknown.

The length of home ranges used by otters in Kelp Bay (1 to 22.5 km of marine shoreline) tended to be shorter than the amount of freshwater stream and lake shoreline (8 to 78 km) used by otters in Idaho (Melquist and Hornocker 1983). Larsen (1983), on Prince of Wales Island, reported otters used home ranges of 19 to 39.9 km of shoreline in a marine system similar to Kelp Bay. In Larsen's study area, a number of otters were taken each year by trappers. This may have contributed to differences in otter densities and sizes of home ranges observed between the two areas.

The marine shore provides an abundance of food for otters and probably less home range is required to provide food needs. Kruuk and Hewson (1978) suggest that the marine shore may be the optimal habitat for the very similar European otter (L. lutra).

Movements

The observed movements of otters were generally in the water and parallel to shore. Most of the movements were less than 100 m from shore, though adult male No. 74 occasionally crossed South Arm (a distance of approximately 1 km) during monitoring periods. The otters also occasionally crossed overland on large points. Other land movements involved traveling to and from the natal den areas (See Reproduction and Denning habitat).

Activities that otters were involved in during observations included: Resting, foraging, swimming, mating,and grooming. Almost all visual observations of otters in the water revealed that they were involved in some aspect of foraging.

The straight-line distance between radio-locations of individual otters on consecutive-days and the straight-line distance between radio-locations of individual otters during the same day (at least one hour apart) were used as indications of the amount of activity exhibited by an otter. Otter movements were considered on a seasonal basis (each season a particular otter was instrumented and available for radio-locating) and for all seasons (every season or entire period during which a particular otter was instrumented). Not all otters were instrumented during all seasons (Table 5), and there were some seasons when only a few or no multiple locations within the same day occurred for a particular otter. The straight-line distance probably did not describe the actual route traveled by the otter along the shore and should be considered minimum.

Same-day movements

The mean distances between radio-locations of individual otters on the same-day are listed in Table 7. A correlation analysis (Table 8) of the distance and amount of time between when each otter was located showed no significant linear relationship between the two variables at the 0.05 significance level with the exception of adult female No. 79 ($r = 0.5608$, $n = 66$, $P < 0.001$). Pooled data for all otters for all seasons also showed no significant linear relationship ($r = -0.0104$, $n = 696$, $P > 0.5$) between the distance and amount of time between same-day locations. Thus, the results indicate that there were no consistent rates of movement. Increased time between radio-locations did not necessarily correlate with the sites being farther apart, allowing same-day locations with different amounts of time between locations to be grouped together for comparisons.

Comparisons between seasons of mean distances between same-day radio-locations for each otter are listed in Appendix G. The same-day movements for male No. 99 were significantly less during summer than during the fall (t test, $P < 0.05$). All other comparisons between

TABLE 7. Seasonal straight-line distances between same-day radio-locations for river otter at Kelp Bay, Alaska. Dashed lines separate family groups.

Otter No.	Season	N	Mean (km)	SD	Range (km)
Male 99	Spring	79	0.31	0.4132	0.0 - 2.4
	Summer	117	0.26	0.2898	0.0 - 1.2
	Fall	58	0.37	0.3468	0.0 - 1.3
	Winter	5	0.14	0.2191	0.0 - 0.5
	Sprg/Sum/Fall	254	0.30	0.3467	0.0 - 2.4
Ad. Fem. 78	Spring	7	0.71	0.5367	0.4 - 1.4
	Summer	58	0.33	0.3620	0.0 - 1.9
	Fall	58	0.37	0.3735	0.0 - 1.4
	Winter	5	0.18	0.1789	0.0 - 0.4
	Sprg/Sum/Fall	123	0.45	1.0636	0.0 - 1.9
	Before denning	2	0.20	0.2828	0.0 , 0.4
	Denning	24	0.59	0.4754	0.0 - 1.4
	After denning	102	0.48	0.3389	0.0 - 1.3
Male pup 97	Fall	20	0.48	0.3708	0.0 - 1.3
- - -	- - -	- - -	- - -	- - -	- - -
Ad. Fem. 71	Summer	7	0.36	0.5318	0.0 - 1.5
	Fall	25	0.62	0.7533	0.0 - 2.6
	Winter	3	1.1	1.5716	0.0 - 2.9
Fem. pup 91	Fall	11	0.76	0.6072	0.1 - 1.9
	Winter	3	0.17	0.1528	0.0 - 0.3
- - -	- - -	- - -	- - -	- - -	- - -
Ad. Fem. 81	Spring	21	0.60	0.7997	0.0 - 2.6
	Summer	47	0.40	0.5920	0.0 - 1.9
	Fall	19	0.31	0.3365	0.0 - 1.1
	Sprg/Sum/Fall	87	0.43	0.3708	0.0 - 2.6
	Before denning	3	0.47	0.8083	0.0 - 1.4
	Denning	56	0.52	0.6918	0.0 - 2.6
	After denning	28	0.26	0.3327	0.0 - 1.1
Fem. pup 70	Summer	4	0.2	0.2449	0.0 - 0.5
	Fall	22	0.40	0.3498	0.0 - 1.2
	Winter	1	-	-	0.6
Fem. pup 76	Summer	4	0.2	0.2449	0.0 - 0.5
	Fall	22	0.32	0.3500	0.0 - 1.2
	Winter	1	-	-	0.6

TABLE 7. (cont.)

Otter No.	Season	N	Mean (km)	SD	Range (km)
Male pup 95	Summer	4	0.23	0.2872	0.0 - 0.6
	Fall	22	0.29	0.3129	0.0 - 1.0
	Winter	1	-	-	0.6
Ad. Fem. 79	Spring	19	0.33	0.3163	0.0 - 0.9
	Summer	34	0.24	0.4061	0.0 - 1.7
	Fall	13	0.04	0.0650	0.0 - 0.2
	Sprg/Sum/Fall	66	0.23	0.1226	0.0 - 1.7
	Before denning	6	0.07	0.1211	0.0 - 0.3
	Denning	17	0.48	0.3557	0.0 - 1.3
	After denning	43	0.15	0.3217	0.0 - 1.7
Ad. Male 74	Spring	6	0.58	0.8728	0.0 - 2.3
	Summer	1	-	-	0.3

TABLE 8. Results of correlation analysis of amount of time between when otters were located and distance between location sites during the same-day at Kelp Bay, Alaska. Dashed lines separate radio-equipped family groups.

Otter No.	N	r	Probability
Male 99	259	0.1145	$0.05 < P < 0.10$
Ad. Fem. 78	128	0.1590	$0.05 < P < 0.10$
Male pup 97	20	0.0877	$P > 0.50$
Ad. Fem. 71	35	0.0083	$P > 0.50$
Fem. pup 91	14	0.1707	$P > 0.50$
Ad. Fem. 81	87	0.1409	$0.10 < P < 0.20$
Fem. pup 70	27	0.1766	$0.20 < P < 0.50$
Fem. pup 76	27	0.2137	$0.20 < P < 0.50$
Male pup 95	26	0.2512	$0.20 < P < 0.50$
Ad. Fem. 79	66	0.5608	$P < 0.001$
Ad. Male 74	7	-0.1041	$P > 0.50$

seasons for this otter showed no significant differences. Adult female No. 78 moved significantly greater distances between same-day locations in the spring than in the summer or fall and significantly greater distances during the denning season (May 6 to July 19) than after (t test, $P < 0.05$). No significant differences were shown between any of the other seasons.

No differences in the distances between same-day radio-locations of adult female No. 71 or female pup No. 91 could be determined between any seasons.

Distances between same-day radio-locations for adult female No. 81 during spring, summer and fall were not significantly different, though distances during the denning season were significantly greater than after denning (t test, $P < 0.05$). Sufficient same-day radio-locations for pups Nos. 70, 76 and 95 were obtained only during summer and fall, and comparisons of the distance between locations of those seasons showed no significant difference for any of those otters. Insufficient same-day radio-locations were obtained for male No. 74 to allow any comparisons between seasons.

Though the linear dependency between time of locations and distance between same-day radio-locations of female No. 79 was significant, there were no significant differences in the time between radio-locations during spring, summer or fall (t test, $P > 0.05$). Because there were no significant differences in the times between radio-locations between the different seasons, seasonal comparisons of the distances between same-day radio-locations for No. 79 were conducted. The distances between same-day radio-locations of No. 79

were significantly less during the fall than for spring or summer (t test, $P < 0.05$), but no significant differences occurred between spring and summer. Distance between same-day radio-locations of No. 79 were significantly greater (t test, $P < 0.05$) during the denning season (May 6 to June 6) than either before or after denning.

A correlation analysis of the distances between same-day radio-locations of each otter with the length of home range during each season and for all seasons, showed no significant linear relationship (each season: $r = 0.1192$, $n = 26$, $0.10 < P < 0.20$, all seasons: $r = 0.2733$, $n = 11$, $0.20 < P < 0.50$). Because the distance between same-day radio-locations did not appear to be dependent upon home range length, comparisons were made between otters, including those which may have had different home range sizes.

Comparisons of the movements of some of the adult-sized otters which inhabited different home ranges (Appendix H) indicated that combined mean distances for spring, summer and fall movements between same-day radio-locations for Nos. 78 and 81 were significantly greater than those for No. 79 (t test, $P < 0.05$). No significant differences could be shown between 78 and 81 or between Nos. 99, 78 and 81 (t test, $P > 0.05$).

Same-day radio-locations for adult male No. 74 were obtained primarily during the spring. Comparisons with other otters of the distance he moved between same-day radio-locations indicated that there were no significant differences between No. 74 and adult females Nos. 78, 79 and 81 or with male No. 99 (t test, $P > 0.05$) during spring.

The only pattern of significant differences in distances between same-day radio-locations appeared to be that of greater movements during the denning periods than after for adult females Nos. 78, 79 and 81. No other patterns emerged, between or within family groups.

Consecutive-day movements

The mean distances between consecutive-day radio-locations for individual otters during each season are listed in Table 9. Seasonal comparisons of movements between consecutive-day radio-locations for each otter are given in Appendix I.

The consecutive-day movements for male No. 99 were significantly greater during the fall than during spring and summer (t test, $P < 0.05$). Comparisons between all other seasons showed no significant differences for this otter. Adult female No. 78 did not appear to have any significant difference in distance moved between consecutive-days for any season. Consecutive-day movements for No. 78 were significantly greater during the denning period (May 6 to July 19) than before denning (t test, $P < 0.05$), but no significant difference was observed between the denning period and the period after she denned.

Consecutive-day movements for adult female No. 71 were significantly less during the summer than during fall or winter (t test, $P < 0.05$), but no difference could be detected between fall and winter. No significant difference between consecutive-day radio-locations occurred between fall and winter for female pup No. 91.

TABLE 9. Summary of information for straight-line distances between consecutive-day radio-locations of river otters at Kelp Bay, Alaska. Dashed lines separate radio-equipped family groups.

Otter No.	Season	N	X (km)	SD	Range (km)
Male 99	Spring	64	0.41	0.4045	0.0 - 1.5
	Summer	80	0.45	0.3065	0.0 - 1.2
	Fall	45	0.63	0.4384	0.0 - 1.4
	Winter	9	0.77	0.6305	0.0 - 1.8
	All seasons	198	0.49	0.3997	0.0 - 1.8
Ad. Fem. 78	Spring	16	0.34	0.5018	0.0 - 1.6
	Summer	57	0.40	0.3794	0.0 - 1.5
	Fall	45	0.51	0.4506	0.0 - 1.6
	Winter	14	0.51	0.5829	0.0 - 1.5
	All seasons	132	0.44	0.4434	0.0 - 1.6
	Before denning				
	Denning	27	0.57	0.4705	0.0 - 1.6
	After denning				
Male pup 97	Fall	11	0.70	0.3033	0.3 - 1.0
- - -	- - -	- - -	- - -	- - -	- - -
Ad. Fem. 71	Summer	17	0.62	0.8159	0.0 - 3.1
	Fall	39	1.36	1.0612	0.0 - 3.4
	Winter	9	1.40	0.8888	0.0 - 2.9
	All seasons	65	1.17	1.0207	0.0 - 3.4
Fem. pup 91	Fall	18	0.97	1.0065	0.0 - 3.3
	Winter	8	1.43	0.9392	0.0 - 2.7
	All seasons	26	1.11	0.9911	0.0 - 3.3
- - -	- - -	- - -	- - -	- - -	- - -
Ad. Fem. 81	Spring	37	0.93	0.9660	0.0 - 3.2
	Summer	70	0.43	0.5191	0.0 - 2.1
	Fall	38	1.01	0.6581	0.0 - 2.3
	Winter	11	0.65	0.5298	0.0.- 1.5
	All seasons	156	0.71	0.7258	0.0 - 3.2
	Before denning				
	Denning	59	0.56	0.6376	0.0 - 1.6
	After denning				
Fem. pup 70	Summer	5	0.22	0.2490	0.0 - 0.6
	Fall	38	0.81	0.5527	0.0 - 2.6
	Winter	9	0.70	0.4717	0.0 - 1.4
	All seasons	52	0.74	0.5405	0.0 - 2.6

TABLE 9. (cont.)

Otter No.	Season	N	X (km)	SD	Range (km)
Fem. pup 76	Summer	5	0.22	0.2490	0.0 - 0.6
	Fall	38	0.84	0.6297	0.0 - 2.6
	Winter	11	0.54	0.4501	0.0 - 1.1
	All seasons	54	0.72	0.6008	0.0 - 2.6
Male pup 95	Summer	5	0.28	0.2168	0.0 - 0.6
	Fall	38	0.91	0.6028	0.0 - 2.6
	Winter	7	0.53	0.4645	0.0 - 1.2
	All seasons	50	0.80	0.5938	0.0 - 2.6
Ad. Fem. 79	Spring	35	0.39	0.3429	0.0 - 1.0
	Summer	62	0.54	0.4380	0.0 - 1.4
	Fall	28	0.12	0.2278	0.0 - 0.7
	Winter	5	0.92	0.2049	0.7 - 1.1
	All seasons	130	0.42	0.4117	0.0 - 1.4
	Before denning				
	Denning	22	0.48	0.3621	0.0 - 1.0
	After denning				
Ad. Male 74	Spring	26	2.20	1.5719	0.0 - 1.0
	Summer	18	0.83	0.8337	0.0 - 2.9
	Fall	1	-	-	1.4
	All seasons	45	1.64	1.4599	0.0 - 6.1

Adult female No. 81 moved significantly greater distances between consecutive-day radio-locations in spring than in summer, but less in summer than in fall (t test, $P < 0.05$). No differences were determined between other seasons. The distance moved between consecutive-days during the denning season (May 3 to July 16) was significantly less than for the period before denning (t test $P < 0.05$), but there were no significant differences between the denning period and after. Female pup No. 70 moved significantly less during the summer than during the fall and winter (t test, $P <0.05$), but no difference was shown between fall and winter. Both female pup No. 76 and male pup No. 95 moved significantly less between consecutive-day radio-locations during summer than fall (t test, $P < 0.05$), but no significant differences were detected between summer and winter or fall and winter for either otter. It should be noted that summer consecutive-day movements were determined on only five occasions for pups Nos. 70, 76 and 95 and these occurred soon after capture and implantation of the transmitter in mid-August, the last month of the summer season.

The distances between consecutive-day radio-locations for adult female No. 79 were significantly greater during spring and summer than fall, but no significant difference was shown between spring and summer (t test $P < 0.05$). No significant differences occurred between any other seasons or between the denning season (May 6 to June 6) and the periods before or after.

Adult male No. 74 moved significantly more between consecutive-day radio-locations during spring than summer (t test, $P < 0.05$). Sufficient consecutive-day radio-locations were not obtained during fall or winter to allow comparisons between other seasons for No. 74, the only adult male followed for any length of time.

There were no apparent seasonal patterns of movements between consecutive-day radio-locations for any of the radio-equipped river otters. With the exceptions of the differences between summer and fall movements for No. 81's family group (Nos. 81, 70, 76 and 95), no intra-group patterns were evident. Similarly, no patterns of consecutive-day movements during the denning seasons for Nos. 78, 79 and 81 were evident.

The mean distances between consecutive-day radio-locations of individual otters were not compared between otters. Correlation analysis indicated that a significant linear relationship existed between the mean distances between consecutive-day radio-locations and home range length for all radio-equipped otters during each season ($r = 0.4003$, $n = 33$, $0.02 < P < 0.05$) and for all-seasons ($r = 0.762$, $n = 11$, $0.002 < P < 0.005$).

No clear patterns of differences in movements for any age, sex or family group emerged for same-day or consecutive-day movements for otters studied at Kelp Bay. Larsen (1983) measured consecutive-day movements for an adult male and one yearling male otter. He found no significant differences between the distances moved during spring and summer, unlike the adult male otter at Kelp Bay. Larsen also found that summer movements for a yearling male were significantly less than fall movements. He indicated this might have been an artifact of the small number of radio-locations of that river otter, all shortly after the surgery to implant a radio-transmitter.

Melquist and Hornocker (1983) measured the distance of the probable route along waterways between consecutive-day locations for otters in Idaho and reported much variability but no apparent trends. Though the actual travel routes they measured were not directly comparable to the straight-line measurements of consecutive-day locations from Kelp Bay, the distance of 42 km by one otter in Idaho far exceeds the maximum observed at Kelp Bay (6.1 km).

Information from 60 periods of continuous monitoring (Appendix J) of radio-equipped otters totaling 149 hours and 31 minutes indicated that straight-line measurements were conservative and should be considered minimum movements. During one such monitoring period of 5 hours and 45 minutes, adult male No. 74 traveled 6.6 km along the shore. The straight-line distance between the beginning and end locations of the monitoring period measured 4 km.

Activity

Activities of otters during observations included: Resting, foraging, playing, swimming, mating and grooming. Information from when the otters were located and for monitoring periods indicated that radio-equipped otters were frequently active during daylight hours. Most of the radio-locations occurred when there was daylight (Table 10). It should be noted that the amount of daylight during the day depended a great deal upon the amount of cloud cover as well as

TABLE 10. Number of radio-locations for each river otter during each hour during entire period each otter was located, Kelp Bay, Alaska. Vertical lines separate family groups or otters that used the same shore area.

Time	Otter Number											
	99	78	97	76M	71	91	81	70	76	95	79	74
2400–0059	2	1	0	0	0	0	1	0	0	0	1	0
0100–0159	0	0	0	0	0	0	0	0	0	0	0	0
0200–0259	0	0	0	0	0	0	0	0	0	0	0	0
0300–0359	0	0	0	0	0	0	0	0	0	0	0	0
0400–0459	0	0	0	0	0	0	0	0	0	0	0	0
0500–0559	0	1	0	0	0	0	0	0	0	0	0	0
0600–0659	15	4	0	0	0	0	1	0	0	0	3	2
0700–0759	31	27	0	0	2	0	22	0	0	0	16	3
0800–0859	27	16	0	0	5	0	4	1	1	1	8	1
0900–0959	67	32	7	0	14	2	27	5	4	4	13	8
1000–1059	42	25	2	2	16	8	26	12	12	10	28	14
1100–1159	38	26	1	0	12	7	29	14	14	16	24	9
1200–1259	31	20	2	1	12	7	27	17	18	18	22	9
1300–1359	32	27	4	0	12	6	22	12	11	12	14	5
1400–1459	22	21	3	0	5	3	20	9	9	8	19	9
1500–1559	20	20	4	0	9	7	12	6	9	5	8	4
1600–1659	21	21	2	0	10	8	10	5	4	5	13	6
1700–1759	29	13	4	0	6	3	24	10	10	9	18	5
1800–1859	34	16	4	0	14	4	16	7	8	8	15	3
1900–1959	32	17	4	1	8	1	11	5	5	5	9	2
2000–2059	30	14	0	1	1	0	15	0	0	0	13	3
2100–2159	18	8	0	0	2	0	10	1	1	1	9	3
2200–2259	6	0	0	0	0	0	2	0	0	0	4	5
2300–2359	2	1	0	0	0	0	6	0	0	0	6	0
unknown	3	1	1	1	0	1	1	1	1	1	1	1
Total	502	311	38	6	128	57	286	105	107	103	244	92

changing seasonally. At 443 (63.6%) of 696 same-day radio-locations, the otters had moved to different sites during the day. On 163 occasions, more than two same-day radio-locations for individual otters were obtained; of these, 33 (20.2%) indicated no measurable movement between the first and the last location sites. Of those 33 same-day radio-locations, the radio-locations between the first and last were at different sites on 10 (30.3%) occasions, indicating the otters moved during the day, then returned to the previously used site. Larsen (1983) concluded that a radio-equipped adult male otter was most active at night, and that an adult female was commonly active during the day. He also reported that the otters usually remained at one site throughout the day.

There was no linear relationship shown between the mean distance between same-day radio-locations and home range length, yet there was a linear relationship between the mean distance between consecutive-day radio-locations and home range length. This suggests that even though the otters were commonly active and moving during the day, activities and movements associated with the use of their entire home range may have been occurring at night or between consecutive-day radio-locations.

The effects of tide level and phase on otter activity were investigated because the tides have a substantial effect on the plant and animal distributions along the shore (Ricketts and Calvin 1968, Carefoot 1977). Information on the activity during radio-locations for all otters for all seasons were grouped and the proportion when the otters were active and in the water (sum of the activity classes: in otters were active and in the water (sum of the activity classes: in water/foraging-feeding and in water/traveling) for each stage of the tide compared. Traveling in water and foraging-feeding were grouped together because the otters swam from one area to another while foraging and movements in water were usually associated with foraging-feeding.

A chi-square analysis of 1964 radio-locations indicated no significant differences in the proportion of active, in water radio-locations between slack, rising or falling tides (chi-square = 0.5996, df. = 2, $0.5 < P < 0.75$). Tidal intervals were constructed (Fig. 4) so that each rising and falling phase of the tide was divided into nine intervals, beginning with a slack period. Each radio-location was assigned to one of these tidal intervals based upon the time of the radio-location in relation to the published time (Anon. 1981) of the previous slack tide for that day. A chi-square analysis did not indicate any significant differences in the proportion of active, in water radio-locations between these tidal intervals (chi-square = 15.6292, df. = 17, ($0.25 < P < 0.50$).

The proportion of radio-locations when the otters were active and in the water in each of the tide intervals of corresponding relative levels for rising and falling tides and slack periods were compared and showed no significant differences (chi-square = 4.9082, df. = 9, $0.75 < P < 0.90$). It should be pointed out that these grouped intervals were for the entire period that radio-equipped otters were located, and each rising and falling tide represents a composite of all spring and neap

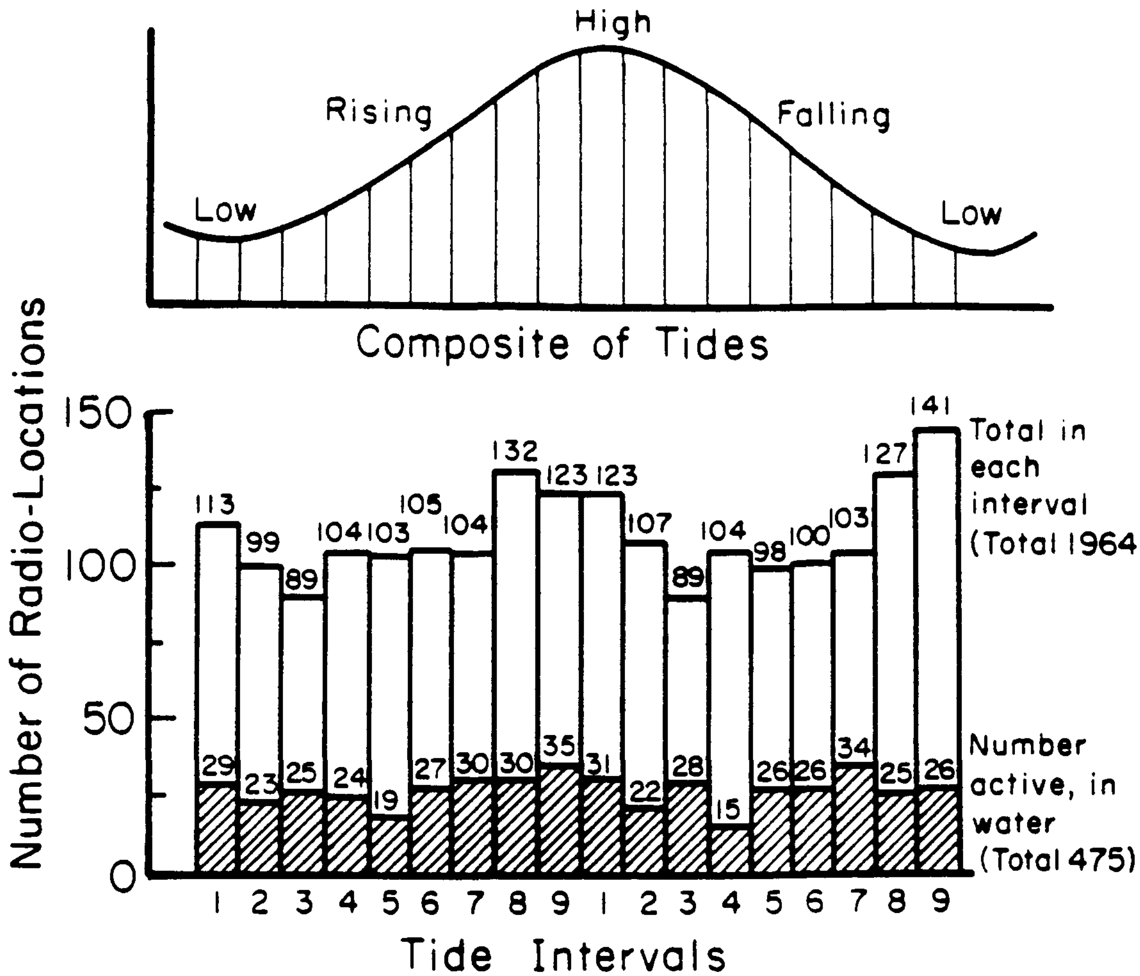

Figure 4. Number of radio-locations of river otters within each tide interval at Kelp Bay, Alaska.

tides.

From the variables measured, it did not appear that otters were selecting any particular stage or level of tide for feeding in the water. Larsen (1983) also did not detect any difference in the number of otters he observed during rising or falling tides at Prince of Wales Island.

A chi-square goodness of fit analysis determined that the radio-locations when the otters were active and in the water were not found in the proportion expected (chi-square = 32.09, df. = 3, $P < 0.001$) in all seasons (Fig. 5). Confidence intervals (Table 11) for the theoretical proportion of occurrence of radio-locations when the otters were active were constructed for each season using the Bonferroni z-statistic (Neu et al. 1974). Radio-locations when the otters were active and in the water were found more often than expected during the winter, less than expected during the summer and as expected during spring and fall ($P < 0.05$).

Liers (1951) reported that river otters increased their travels during the breeding season and Larsen (1983) suggested that adult males might improve their chances of breeding by "patrolling" smaller areas but moving more often. The breeding season for otters in Kelp Bay (and probably in all of southeastern Alaska) was fairly well established as May during this study. Most of the spring radio-locations for adult male No. 74 occurred in late April and May. It was determined that this adult male moved further between consecutive-day radio-locations in spring than summer and his spring home range was larger than summer or fall. Unfortunately, insufficient same-day radio-locations were

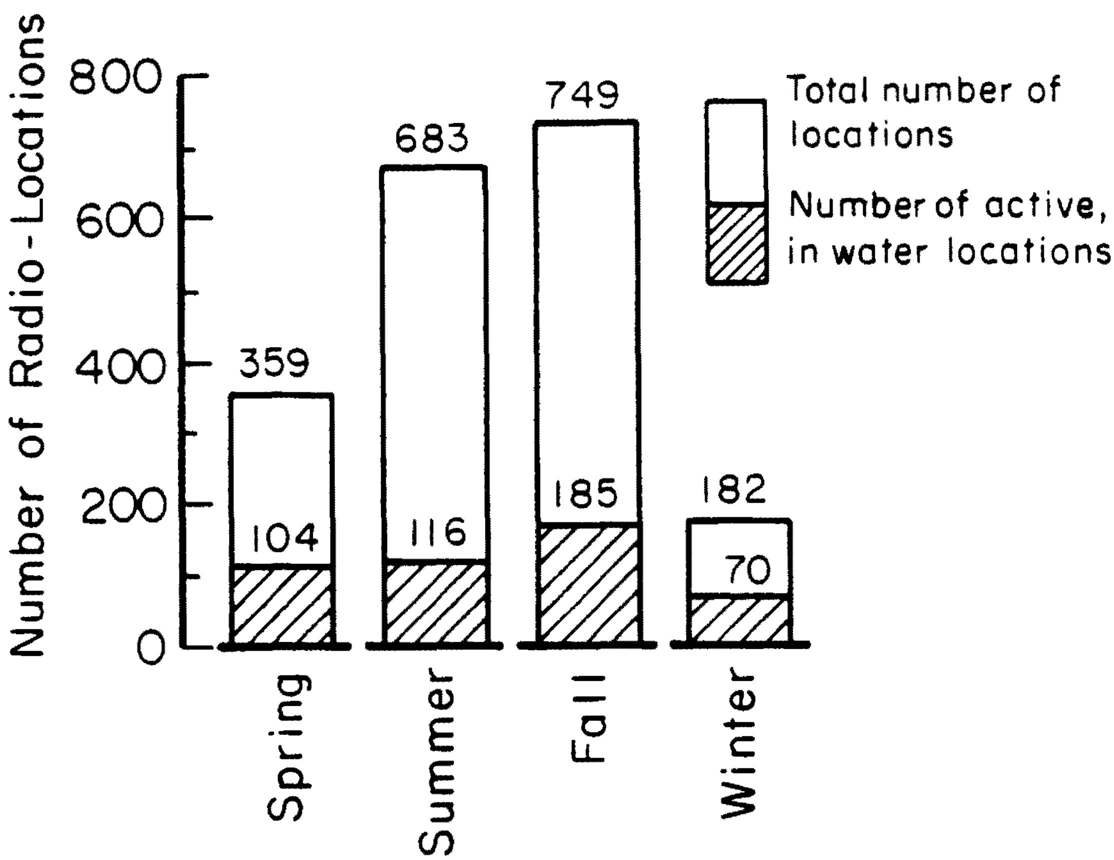

Figure 5. Number of radio-locations per season and number of radio-locations when river otters were active and in the water for each season at Kelp Bay, Alaska.

TABLE 11. Total number of radio-locations and number of radio-locations when river otters were active and in water for each season at Kelp Bay, Alaska. Expected number of active radio-locations represents the number of active radio-locations that would be expected in each season if the active radio-locations for each season occurred in equal proportion to the total number of radio-locations for that season.

Season	Number of locations per season (l_i)	Prop. of total locations[a] (p_{io})	Number of active locations (n_i)	Expect. No. of active locations[b]	Prop. of active locations[c] ($\hat{p}_i$)	95% Confidence Interval on proportion of occurrence[d] (P_i)
Spring	359	0.18	104	86	0.2189	$0.1715 \leq P_1 \leq 0.2663$
Summer	683	0.35	116	164	0.2442	$0.1949 \leq P_2 \leq 0.2935$
Fall	749	0.38	185	180	0.3895	$0.3336 \leq P_3 \leq 0.4454$
Winter	182	0.09	70	45	0.1474	$0.1067 \leq P_4 \leq 0.1881$
	L = 1973	1.0	N = 475	475	1.0	

[a]Number of locations per season divided by the total number of locations. (l_i / 1973)
[b]Multiply total number of locations by proportion of total locations in each season. (N x p_{io})
[c]Number of active locations in each season divided by total number of active locations. (n_i / 475)
[d]Confidence Interval = $\hat{p}_i \pm \{Z[1-0.05/8]\ [\hat{p}_i(1-\hat{p}_i)/475]^{1/2}\}$
(P_i) represents the theoretical proportion of occurrence. If p_{io} is less than the confidence interval, radio-locations when the otters were active and in the water occurred more frequently than expected. If p_{io} is greater than the confidence interval, radio-locations when the otters were active and in the water occurred less than expected.

obtained for No. 74 in summer and fall to determine if there were any differences in same-day movements between seasons.

The likelihood of visual observations of the otters during radio-locations was very unpredictable with the exception of the pups in November and December. During those months, it was often quite easy to approach pups with the boat while they were foraging. Prior to November, most of the radio-locations for the pups occurred with radio-locations for the adult females and the otters often left the water at the approach of the boat.

SUMMARY

Home range was determined for 11 river otters inhabiting parts of Kelp Bay. Home range was considered the length of the marine shoreline used by the otters. The otters appeared to move freely and frequently throughout their home ranges. The otters commonly moved throughout the entire length of their home range within a day or two. The otters did not appear to travel in their home ranges in a circuital route. There was no evidence to suggest that the otters were traveling between the larger islands or that their home ranges were larger than what was determined.

Spring home range length for one adult male was longer than the home range used during the rest of the year and longer than the relatively stable home ranges used by radioed family groups.

Four family groups used adjacent but essentially non-overlapping shoreline home ranges. The home ranges at Kelp Bay tended to be smaller than areas reported in other studies, possibly due to the abundant food supply along the coast or lack of disturbance by humans.

Most of the movements by otters involved traveling in water. There were no apparent patterns of movement activity revealed by measurements of straight-line distances between radio-locations on consecutive-days. Straight-line distances between same-day radio-locations appeared to be greater during the denning season than after for three adult females known to have used natal dens.

No differences in activity during all phases of the tide were detected and the radio-equipped otters were frequently observed foraging during the day. The otters appeared to be most active during radio-locations in winter and the least active in summer.

HABITAT USE

Introduction

The use of habitats by river otters in North America has only recently begun to be investigated. Otters are primarily adapted for aquatic travel and foraging but make use of terrestrial areas for a variety of purposes such as traveling between bodies of water, resting sites and natal dens. Most use of terrestrial habitat is restricted to a narrow fringe adjacent to the water (Larsen 1983, Melquist et al. 1983, Melquist and Hornocker 1983, Reid 1982, 1983).

Resource managers have had difficulty in determining the kinds of areas that might be valuable to otters and how land management practices might affect use by otters. The information presented here includes the first descriptions of natal dens for river otters using a marine environment in North America.

Objectives for this section of the study included:

1. To determine use of habitat by river otters in Kelp Bay, Baranof Island, Alaska.

2. To determine characteristics of the habitat at river otter natal den areas.

Results and discussion

The characteristics of the habitat used by river otters at a radio-location and for sites (and use areas) used by river otters are presented in this section. Radio-locations indicate the number of times an otter (or group of otters) was located in a particular habitat type and reflect the amount of time an otter (or group of otters) spent within a particular type of habitat. Multiple radio-locations per site were common (Table 12), but for analysis, the characteristics of the habitat for a specific site were considered only once.

Forest characteristics

One radio-location per day for an individual radio-equipped otter or group of radio-equipped otters that were at the same site was randomly selected to determine habitat use. This procedure was followed so that the site at which a radio-equipped otter was located was assumed to be independent of the previous or following radio-locations. When two or more radio-equipped otters were located together, the habitat characteristics were considered only once. This reduced the number of usable radio-locations from 1973 to 963. Of the 963, 212 radio-locations occurred while the otters were in the water and were not used in the determination of terrestrial habitat utilization. The otters were determined to be within 30 m of shore in

TABLE 12. Number of radio-locations per site at Kelp Bay, Alaska.

Number of radio-locations per individual site	Number of sites	Total number of radio-locations
1	277	277
2	42	84
3	19	57
3	10	40
5	4	20
6	3	18
7	4	28
8	4	32
9	3	27
10	4	40
11	2	22
12	2	24
16	1	16
17	1	17
23	1	23
26	1	26
	378	751

566 (75.4%) of the remaining 751 radio-locations. The number of radio-locations when the otters were in each of the other distance categories are listed in Table 13.

Of the 378 sites where radio-equipped otters were located, 278 (73.5%) were within 30 meters of shore. Table 13 includes the number of sites within each of the distance catagories.

Distance of the otters from shore at radio-locations and distance from shore of sites used by otters was determined for each season (Table 14). The otters were within 30 m of shore for most of the radio-locations in each of the seasons, as were most of the sites. Part of the increased number of radio-locations farther inland during spring and summer reflect the use of the inland natal den areas (see Denning habitat). Not all of the radio-equipped otters were instrumented during each of the four seasons, but information was obtained for at least one individual of each family group and for adult male No. 74 during all seasons.

Larsen (1983), working on Prince of Wales Island in southeastern Alaska, found that most burrows used by otters were between 0.9 and 22.9 m (mean = 5.4 m) of shore. Kruuk and Hewson (1978) found similar use of the marine shoreline by L. lutra in Europe, with most terrestrial use confined to within 20 m of shore. Sites used by otters in west central Idaho (Melquist et al. 1981, Melquist and Hornocker 1983) and Alberta, Canada (Reid 1982, 1983) were near ponds, lakes and streams and were associated with feeding and resting areas. Larsen (1983) determined that marine fish were the most common food items taken by otters living along the coast. Only a small amount of

TABLE 13. Distance from shore of river otters at radio-locations and distance from shore of sites used by radio-equipped river otters

Distance from shore	Number of radio-locations	(%)	Number of sites	(%)
within 30 m	566	(75.37)	278	(73.54)
30–100 m	68	(9.05)	46	(12.54)
100–400 m	53	(7.06)	31	(8.20)
> 400 m	43	(5.73)	6	(1.59)
other[a]	7	(0.93)	4	(1.06)
unknown	14	(1.86)	13	(3.44)
	751		378	

[a]Includes those not easily classified into the above categories.

TABLE 14. Distance from shore of river otters at radio-locations and distance from shore of sites[a] used by river otters during each season at Kelp Bay, Alaska.

Distance		Spring		Summer		Fall		Winter	
		No.	(%)	No.	(%)	No.	(%)	No.	(%)
within 30 m	locations	100	(62.1)	217	(72.1)	183	(84.3)	66	(91.7)
	sites	71	(66.4)	125	(72.7)	108	(83.7)	38	(88.4)
30-100 m	locations	13	(8.1)	40	(13.3)	11	(5.1)	4	(5.6)
	sites	12	(11.2)	28	(16.3)	8	(6.2)	3	(7.0)
100-400 m	locations	27	(16.8)	7	(2.3)	18	(8.3)	1	(1.4)
	sites	17	(15.9)	6	(3.5)	9	(7.0)	1	(2.3)
> 400 m	locations	16	(9.9)	27	(9.0)	-	-	-	-
	sites	2	(1.9)	6	(3.5)	-	-	-	-
other	locations	1	(0.6)	4	(1.3)	2	(0.9)	-	-
	sites	1	(0.9)	2	(1.2)	1	(0.8)	-	-
unknown	locations	4	(2.5)	6	(2.0)	3	(1.4)	1	(2.3)
	sites	4	(3.7)	5	(2.9)	3	(2.3)	1	(1.4)
Total	locations	161		301		217		72	
	sites	107		172		129		43	

[a]A particular site might have been used during more than one season, or it might not have been used during a season, therefore, number of sites for each season does not total 378 (from Table 13) or equal total for each distance classification from Table 13.

overland travel would be required by otters along the coast to go between feeding and resting areas.

Other than the inland natal den areas, the only other substantial use of inland areas was by adult male No. 74. He frequently traveled at least 1.5 km up Clear and Glacial Rivers from July through mid-November. That period corresponded with the spawning runs of pink and chum salmon (July-August) and with the appearance of Dolly Varden in the rivers (R. Armstrong, pers. comm.). Radio-locations indicated that he remained in the river bottoms.

Because the live-trapping for otters was conducted only along the shoreline, a question could be raised as to whether there might have been otters in the area that used only inland areas or used the shoreline areas only during certain seasons. The northeastern part Baranof Island has little inland aquatic habitat. During the winters, even this would probably be unavailable because of ice and deep snow. I had no evidence that there were otters that used only inland areas.

The USFS has developed Timber Type maps that include the Kelp Bay area. The information on these maps includes forest type (species of trees), stand size, density classes and volume class (net board feet per acre). According to the maps provided by the Sitka Ranger District, TNF, most of the forest habitat in the Kelp Bay study area was uneven-aged old-growth hemlock/spruce or hemlock, well stocked, saw timber classes of 8000 to 20,000 and 20,000 to 30,000 board feet per acre. Most of the area along the shore in the home ranges of the four family groups of radio-equipped otters corresponded with this description.

Table 15 shows the specific vegetation type and species combinations recorded at the 751 radio-locations and of the 378 sites used by radio-equipped river otters. The predominant vegetation type was uneven-aged old-growth forest during radio-locations of otters and at sites (90.3% and 87.8%) respectively). The predominant vegetation species were hemlock/spruce at 293 (39.0%) radio-locations and at 163 (43.1%) of the sites, and hemlock at in 239 (31.8%) radio-locations and at 87 (23.0%) of the sites. The predominant vegetation species were not determined for 103 (13.7%) of the radio-locations or for 88 (23.3%) of the sites. The vegetation of inland sites was difficult to determine when locating from the boat because of the mosaic patterns of the forest. Additional difficulties were encountered when locating after dark or when otters were moving when located.

Use areas were specific sites within the four family groups' home ranges with three or more radio-locations. In several intances two sites were close together and interconnected with trails or extensive burrow systems and were considered one use area. The habitat characteristics of the natal den areas were not analyzed with use areas. Table 16 shows the number of use areas and the number of radio-locations at each.

Of the 44 use areas, 40 (90.9%) were in uneven-aged old-growth forest and four (9.1%) were in leave strips, none were in clearcuts, mixed conifer/deciduous, muskegs or conifer regrowth. The dominant tree species at these areas were hemlock/spruce in 26 (59.1%) areas, hemlock in 15 (34.1%) use areas and hemlock/cedar in three (6.8%) use areas. Spruce, cedar and alders did not predominate in any use area.

Table 15. Forest vegetation type and species at radio-locations of river otters (L) and at sites (S) used by radio-equipped otters at Kelp Bay, Alaska.

SPECIES		FOREST TYPE								
		Uneven-aged old-growth	Clear cut	Leave-strip	Conifer regrowth	Muskeg	Tidal flats	Other	Unknown	Totals (%)
Hemlock	L =	226		11				2		239 (31.8)
	S =	82		4				1		87 (23.0)
Spruce	L =	1								1 (0.1)
	S =	1								1 (0.3)
Cedar	L =	29								29 (3.9)
	S =	3								3 (0.8)
Hemlock/ spruce	L =	258		35						293 (39.0)
	S =	142		21						163 (43.1)
Hemlock/ cedar	L =	61								61 (16.1)
	S =	15								15 (4.0)
Conifer/ deciduous	L =	7								7 (0.9)
	S =	6								6 (1.6)
Alders	L =							4		4 (0.5)
	S =							3		3 (0.8)
Grass	L =						7			7 (0.9)
	S =						6			6 (1.6)
Other	L =	1		4				2		7 (0.9)
	S =	1		3				2		6 (1.6)
Unknown	L =	95		1	1				6	103 (13.7)
	S =	82		1	1				4	88 (23.3)
		(%)		(%)	(%)		(%)	(%)	(%)	
Totals	L =	678 (90.3)	0	51 (6.8)	1 (0.1)	0	7 (0.9)	8 (1.1)	6	751
	S =	332 (87.8)	0	29 (7.7)	1 (0.3)	0	6 (1.6)	6 (1.6)	4 (1.1)	378

TABLE 16. Number of radio-locations per use area for radio-equipped river otter family groups in Kelp Bay, Alaska.

Number of radio-locations per individual use area	Number of use areas	Total number of locations
3	3	9
4	5	20
5	7	35
6	2	12
7	4	28
8	3	24
9	1	9
10	4	40
11	1	11
12	2	24
13	2	26
14	2	28
16	3	48
17	3	51
34	1	34
40	1	40
	44	439

In 21 (47.7%) use areas, the crown closure was 41 to 60%. Crown closure was 21 to 40% in 17 (38.6%) use areas, 61 to 80% in six (13.6%) and no use area had crown closure of 0 to 20% or 81 to 100%. The predominant tree height in these use areas was 24 to 30 m in 25 (56.8%) areas and 16 to 23 m in ten (22.7%) areas. Eight (18.2%) use areas had trees greater that 30 m and in one area (2.3%), trees were less than 15 m. The crown diameter was 7 to 12 m in 27 (61.4%) areas, greater than 13 m in ten (22.7%) areas and 3 to 6 m in seven (15.9%) areas.

A striking characteristic of many of the use areas was the lack of undergrowth in the area surrounding the burrows. Not only were tree seedlings, Vaccinium spp.and rusty menziesia absent, but forbs common in the surrounding forest were absent. The forest floor for many of these areas consisted of hard packed moss and well worn trails. Why these areas were free of undergrowth is uncertain, but long-term use by otters could be suspected. Evidence for this included the hard-packed moss layers, extensive systems of well worn burrows, trails and large and evidently old scat piles. At several areas, heavy wires used to anchor otter traps were deeply embedded into the trees or roots the wires had been wrapped around, suggesting that trappers had trapped for otters at the sites many years ago.

Larsen (1983) found that river otters along the coastal marine environment apparently used the terrestrial habitat near the shoreline in proportion to the amount available with the exception of clear cut areas, which were used less than expected. At Kelp Bay, uneven-aged old-growth hemlock/spruce and hemlock was clearly the predominant forest.

An early objective of this project was to relate information on use of habitats by otters to a forest habitat mapping system (Integrated Resource Inventory) being developed by the Chatham Area, TNF. The minimum size of the Forest Service's mapping units (approximately 10 ha) was later determined to be too coarse in resolution to describe the habitat characteristics at radio-locations of the otters. In addition, the habitat mapping system was developed with emphasis on describing the inland environment and, in a number of areas, did not clearly describe the habitat along the shore at Kelp Bay.

Approximately 2.7 km^2 of clear cut area was present near the home ranges of the family groups associated with adult females Nos. 71, 78 and 81. I documented otters being in the clear cuts in only two instances, neither of which was a radio-location. The first was on a steep, snow covered slope, near the only area within the family groups' home ranges where clear cut extended all the way to the shore. The tracks of one otter were followed along the edge of the uneven-aged old-growth forest and clear cut about 250 m inland and about 100 to 125 m elevation. The tracks turned into the clear cut where the otter dug a small hole in the snow, then proceeded to slide to the bottom of the hill. In the second observation, otter tracks were found on an abandoned logging road 0.6 km inland. The otter was alternately running and sliding in the snow on the road. How long the otter remained in the cut area was unknown.

Leave-strips of 50 to 100 m or more remained between cut areas and the shore in most of the study area. Because most of the radio-locations and sites used by the otters were within 30 m of shore, this logging probably did not greatly affect the otters' use of shorelines at Kelp Bay. In Larsen's study area (Cholmondeley Sound, Prince of Wales Island) the forest was cut all the way to tideline in some places, and the otters clearly avoided those areas.

Disturbances caused by future clear cutting along the shore would change the characteristics of these areas so that otter might not use them. A problem frequently associated with clear cut logging is wind throw of trees along the edge of the cut area. Inadequate leave strips along the shore would be particularly vulnerable. Burrows used by otters at the base of trees would likely be destroyed when the trees were blown down. Soil loosened by logging, road construction or wind throw could be washed into the burrows by heavy rain and dense undergrowth could result from removing the canopy. Slash left by the logging operation would likely impede travel by otters in those areas.

Shore characteristcs

The predominant configuration of the shore at 751 radio-locations of otters, and at 378 sites and 44 use areas was convex (points) (Table 17). The forest above concave shores (beaches or bights) was used infrequently. The total amount of each shore configuration in the four family groups' home range was not determined, but the amount of shoreline in convex and concave shore configuration classes appeared to be similar.

Table 17. The configuration of the shore recorded at radio-locations of river otters, at sites used by radio-equipped river otters and at use areas of river otters at Kelp Bay, Alaska.

Shore configuration class	Number of radio-locations	Number of sites	Number of use areas
Convex	340	132	29
Straight	165	99	11
Concave	42	30	2
Offshore rocks	2	2	0
Not at shore	162	81	2
Other[a]	16	12	0
Unknown	24	22	0
	751	378	44

[a]Includes those not easily classified into the above categories.

Analyses of the shore slope and material adjacent to where otters were radio-located within 30 m of shore and at sites within 30 m of shore, were conducted for the four family groups. The entire shoreline home range for each of these family groups was mapped for shore slope and material (Appendix F). Shore material class small rock occurred infrequently and was grouped together with gravel, sand and mudflat as "fines" for analysis. Medium and large rock classes were grouped together as large rock. Analysis was conducted to determine if family groups used the different shore types in the amount that was available.

A chi-square goodness of fit analysis determined that for all seasons combined, for the radio-locations along the shore, the otters were not found in the shore classifications in the amount expected (chi-square = 224.004, 13 df., $P < 0.001$). Confidence intervals (Table 18) for the theoretical proportion of occurrence were constructed using the Bonferroni Z-statistic (Neu et al. 1974). For radio-locations, the otters were found more often than expected ($p < 0.05$) adjacent to shores of 41 to 60^{o}/solid rock, 61 to 90^{o}/solid rock and 41 to 60^{o}/large rock. The otters were found less often than expected ($p < 0.05$) adjacent to shores of 0 to 20^{o}/solid rock, 0 to 20^{o}/large rock, 0 to 20^{o}/fines and 0 to 20^{o}/mixed. All other shore classifications were used as expected ($p < 0.05$).

A chi-square goodness of fit analysis also determined that for all seasons combined, the sites where otter were located on one or more occasions were not found in the shore classifications in the amount expected (chi-square = 42.104, 13 df., $P < 0.001$). Confidence intervals (Table 19) for the theoretical proportion of occurrence

TABLE 18. Shore types used by otters at radio-locations for all radio-equipped river otter family groups during all seasons at Kelp Bay, Alaska. The expected number of locations represents the number of radio-locations that would be expected in each shore type if the radio-locations occurred in equal proportion to the amount of available shore of that type. (Neu et al. 1974)

Shore type	Avail. shore (km)	Prop. of total shore[a] (p_{io})	Number of radio-locations (n_i)	Expected number of radio-locations[b]	Proportion observed in each type[c] ($\hat{p}_i$)	95% Confidence Interval on proportion of occurrence[d] (P_i)
0-20°/Solid	0.33	0.015	2	6.9	0.004	$0.000 \leq P_1 \leq 0.013$
21-40°/Solid	3.69	0.172	64	79.3	0.139	$0.092 \leq P_2 \leq 0.186$
41-60°/Solid	4.05	0.198	139	87.1	0.302	$0.239 \leq P_3 \leq 0.365$
61-90°/Solid	1.66	0.078	69	36.0	0.150	$0.101 \leq P_4 \leq 0.198$
0-20°/Large	0.72	0.034	5	15.7	0.011	$0.0 \leq P_5 \leq 0.025$
21-40°/Large	2.39	0.112	37	51.6	0.080	$0.043 \leq P_6 \leq 0.117$
41-60°/Large	0.80	0.037	55	17.1	0.119	$0.075 \leq P_7 \leq 0.163$
61-90°/Large	0.16	0.008	1	3.7	0.002	$0.0 \leq P_8 \leq 0.008$
0-20°/Fines	3.59	0.168	20	77.4	0.043	$0.016 \leq P_9 \leq 0.071$
21-40°/Fines	0.01	0.0004	1	0.2	0.002	$0.0 \leq P_{10} \leq 0.008$
0-21°/Mixed	2.07	0.097	21	44.7	0.046	$0.017 \leq P_{11} \leq 0.074$
21-40°/Mixed	1.03	0.048	29	22.1	0.063	$0.030 \leq P_{12} \leq 0.096$
41-60°/Mixed	0.34	0.016	9	7.4	0.020	$0.001 \leq P_{13} \leq 0.038$
Var. /Mixed	0.56	0.026	9	12.0	0.020	$0.001 \leq P_{14} \leq 0.038$
	21.4		461			

[a]Available shore type divided by total amount of shore. (n_i / 21.4)
[b]Multiply total number of locations by proportion of total shore in each shore type. (p_{io} x 461)
[c]Number of locations in each shore type divided by total number of locations. (n_i / 461)
[d]Confidence Interval = $\hat{p}_i \pm \{Z[1-.05/28]\ [\hat{p}_i(1-\hat{p}_i)/461]^{1/2}\}$
(P_i) represents the theoretical proportion of occurrence. If p_{io} is less than the confidence interval, radio-locations occured more frequently than expected. If p_{io} is greater than the confidence interval, radio-locations occurred less than expected.

TABLE 19. Shore types at sites used by otters for all radio-equipped river otter family groups during all seasons at Kelp Bay, Alaska. The expected number of sites represents the number of sites that would be expected in each shore type if the sites occurred in equal proportion to the amount of available shore of that type. (Neu et al. 1974)

Shore type	Avail. shore (km)	Prop. of total shore[a] (p_{io})	Number of sites observed (n_i)	Expected number of sites[b]	Proportion observed in each type[c] ($\hat{p}_i$)	95% Confidence Interval on proportion of occurrence[d] (P_i)
0-20°/Solid	0.33	0.015	2	2.8	0.011	$0.0 \leq P_1 \leq 0.032$
21-40°/Solid	3.69	0.172	32	32.3	0.170	$0.090 \leq P_2 \leq 0.250$
41-60°/Solid	4.05	0.198	42	35.5	0.223	$0.135 \leq P_3 \leq 0.312$
61-90°/Solid	1.66	0.078	20	14.7	0.106	$0.041 \leq P_4 \leq 0.172$
0-20°/Large	0.72	0.034	4	6.4	0.021	$0.0 \leq P_5 \leq 0.052$
21-40°/Large	2.39	0.112	18	21.1	0.096	$0.033 \leq P_6 \leq 0.158$
41-60°/Large	0.80	0.037	18	7.0	0.096	$0.033 \leq P_7 \leq 0.158$
61-90°/Large	0.16	0.008	1	1.5	0.005	$0.0 \leq P_8 \leq 0.021$
0-20°/Fines	3.59	0.168	12	31.6	0.064	$0.012 \leq P_9 \leq 0.116$
21-40°/Fines	0.01	0.0004	1	0.1	0.005	$0.0 \leq P_{10} \leq 0.021$
0-21°/Mixed	2.07	0.097	18	18.2	0.096	$0.033 \leq P_{11} \leq 0.158$
21-40°/Mixed	1.03	0.048	12	9.0	0.064	$0.012 \leq P_{12} \leq 0.116$
41-60°/Mixed	0.34	0.016	4	3.0	0.021	$0.0 \leq P_{13} \leq 0.052$
Var. /Mixed	0.56	0.026	4	4.9	0.021	$0.0 \leq P_{14} \leq 0.052$
	21.4		188			

[a]Available shore type divided by total amount of shore. (n_i / 21.4)
[b]Multiply total number of sites by proportion of total shore in each shore type. (p_{io} x 188)
[c]Number of sites in each shore type divided by total number of sites. (n_i / 461)
[d]Confidence Interval = $\hat{p}_i \pm \{Z[1-.05/28]\ [\hat{p}_i(1-\hat{p}_i)/461]^{1/2}\}$
(P_i) represents the theoretical proportion of occurrence. If p_{io} is less than the confidence interval, sites occurred more frequently than expected. If p_{io} is greater than the confidence interval, sites occurred less than expected.

constructed using the Bonferroni Z-statistic (Neu et al. 1974) indicated that sites of otter use were found significantly less than expected adjacent to shores of 0 to 20^{o}/fines. All other shore classifications were used as expected ($p < 0.05$).

Log-likelihood ratio tests for goodness of fit (Zar 1974) revealed that during each of the four seasons, radio-locations of otters and sites used by the radio-equipped otters (Table 20) were not found in the classifications in the amount expected ($p < 0.05$). Insufficient radio-locations and sites during particular seasons prevented determination of confidence intervals for the theoretical proportion of occurrence for each shore classifications for each season.

An examination of the mean number of radio-locations of otters and sites per 100 m of shore of each of the shore classifications (Tables 21 and 22) also indicated that the areas of steep shore with solid or large rocks were generally used more by otters.

Larsen (1983) found that otters on Prince of Wales Island in southeastern Alaska, selected areas adjacent to shores with a predominance of bedrock and short intertidal lengths. The method used at Kelp Bay to describe the slope of the shore is comparable to intertidal length, with steeper slopes corresponding to shorter intertidal lengths. This method was not dependent upon directly measuring or estimating the intertidal length, which required that the exact mean low tide mark be determined. Instead it required only that the slope of the shore and the amount of tidal fluctuation be known. Figure 6 shows the relationship between shore slope and intertidal

TABLE 20. Results of log-likelihood ratio for the use of shore types during each season by river otters at Kelp Bay, Alaska. Null hypothesis: use of shore type was proportional to the amount of each shore type available. Calculated G statistic is compared with chi-square value.

Season		G[a]	Chi-square[b]	Result
Spring				
	Radio-locations	64.85	21.026	$P < 0.001$
	Sites	40.08	21.026	$P < 0.001$
Summer				
	Radio-locations	136.24	22.362	$P < 0.001$
	Sites	48.68	22.362	$P < 0.001$
Fall				
	Radio-locations	65.27	22.362	$P < 0.001$
	Sites	24.01	22.362	$0.025 < P < 0.050$
Winter				
	Radio-locations	45.19	22.362	$P < 0.001$
	Sites	27.59	22.362	$0.010 < P < 0.025$

[a]G = 4.60517 [sum (observed x Log_{10} observed) - sum(observed X Log_{10} expected)] (Zar 1974)

[b]Spring, chi-square (12, 0.05)
Summer, Fall, Winter, chi-square (13, 0.05)

TABLE 21. Mean number of radio-locations of otters per 100 m of each shore type in the home ranges used by radio-equipped river otter family groups at Kelp Bay, Alaska.

	SEASONS				
Shore type	Spring	Summer	Fall	Winter	All Seasons
0-20°/Solid	0.00	0.32	0.00	0.32	0.60
21-40°/Solid	0.32	0.56	1.17	0.63	1.73
41-60°/Solid	1.43	2.25	1.25	0.85	3.43
61-90°/Solid	1.13	2.92	0.92	0.22	4.17
0-20°/Large	0.00	0.00	0.93	0.34	0.70
21-40°/Large	0.22	0.51	0.76	0.56	1.55
41-60°/Large	2.20	3.60	2.71	0.47	6.86
61-90°/Large	0.00	0.00	0.00	6.67[a]	0.63
0-20°/Fines	0.24	0.36	0.27	0.00	0.56
21-40°/Fines	-[b]	0.00	7.14[c]	0.00	7.14[c]
0-21°/Mixed	0.00	0.36	0.64	0.17	1.02
21-40°/Mixed	0.95	2.74	0.43	0.25	2.82
41-60°/Mixed	0.84	1.35	0.93	0.00	2.68
Var. /Mixed	0.00	2.15	0.00	0.00	1.60

[a]One location in approximately 15 m of shore type.
[b]Shore type did not occur within home ranges in spring.
[c]One location in approximately 14 m of shore type.

TABLE 22. Mean number of sites used by otters per 100 m of each shore type in the home ranges used by radio-equipped river otter family groups at Kelp Bay, Alaska.

	SEASONS				
Shore type	Spring	Summer	Fall	Winter	All Seasons
0-20°/Solid	0.00	0.32	0.00	0.32	0.60
21-40°/Solid	0.11	0.45	0.73	0.29	0.87
41-60°/Solid	0.78	1.08	0.56	0.45	1.04
61-90°/Solid	0.52	1.24	0.35	0.14	1.21
0-20°/Large	0.00	0.00	0.70	0.34	0.56
21-40°/Large	0.11	0.29	0.51	0.25	0.75
41-60°/Large	1.39	2.06	0.60	0.31	2.24
61-90°/Large	0.00	0.00	0.69	6.67[a]	0.63
0-20°/Fines	0.24	0.24	0.20	0.00	0.33
21-40°/Fines	–[b]	0.00	7.14[c]	0.00	7.14[c]
0-21°/Mixed	0.00	0.30	0.64	0.11	0.87
21-40°/Mixed	0.95	0.76	0.43	0.13	1.17
41-60°/Mixed	0.84	1.01	0.31	0.00	1.19
Var. /Mixed	0.00	0.96	0.00	0.00	0.71

[a]One site in approximately 15 m of shore type.
[b]Shore type did not occur within home ranges in spring.
[c]One site in approximately 14 m of shore type.

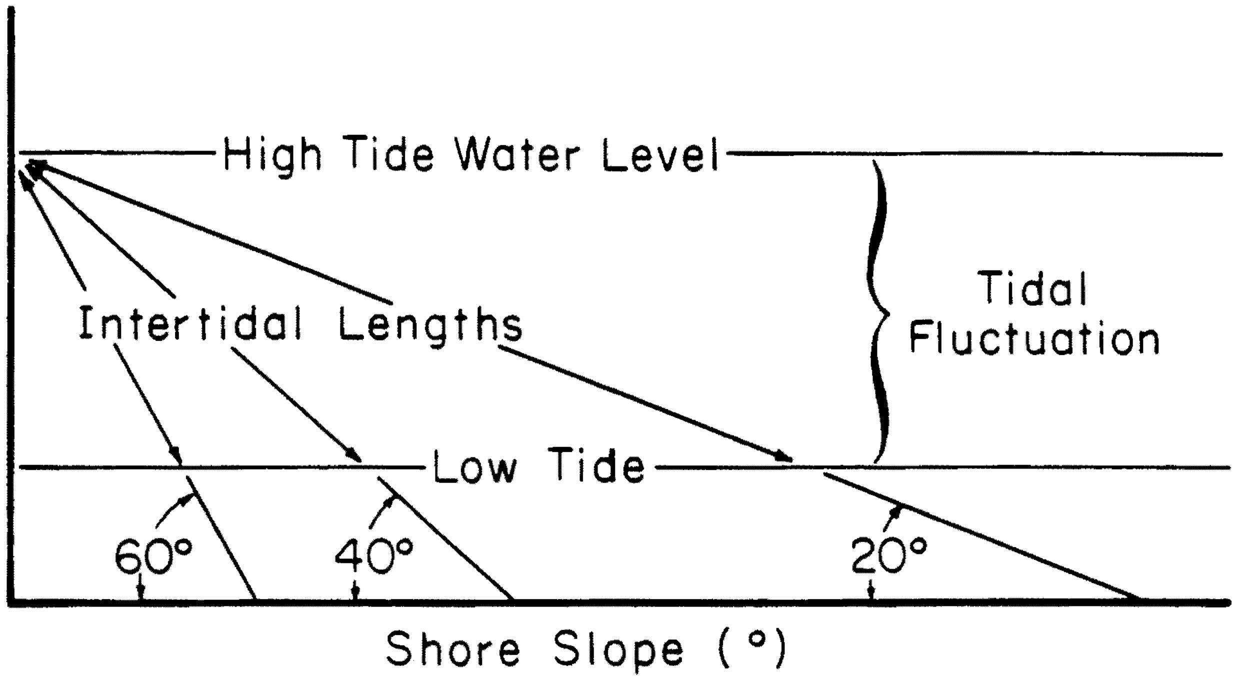

Figure 6. Relationship between shore slope and intertidal length.

length. The amount of intertidal zone exposed is dependent upon the amount of tidal fluctuation and changes from day to day throughout the year.

Larsen (1983) suggested two possible reasons why otters might select areas above steep intertidal zones: presence of the prey species associated with those types of areas and the shorter distances between the water and the forest. The fish found most often in otter scat analysis by Larsen (1983) indicated that otters fed predominantly on fish one would expect to find near steep, rocky shores (cottids, scorpaenids and hexagramids). Fish that would be expected in shallow sloped mud, sand or gravel areas (pholid and stichaeids) were found less frequently.

The difference in the volume of water (or area where the otter's prey can occur) available in intertidal areas as the tide level rises and falls might also be important in relation to prey availability. For similar distances from shore, the volume could be very different in areas with different shore slopes and configurations. In areas of shallow slope, fish must move away from shore as the tide goes out. In steep intertidal areas, the aquatic prey can easily move down as well as away from the shore. This may allow higher concentrations of prey in areas closer to shore. The nature of the rock substrate of steep intertidal areas (i.e., with cracks and spaces between rocks) may also allow higher numbers of prey.

At low tide, an otter traveling between the forest and the water in areas with steep shore slope would be exposed for less time than in areas with more gradual slope. This raises the question of exposed to what? Larsen (1983) suggested that trapping pressure and harrassment may have contributed to the apparent reluctance of otters to cross the exposed shores and use the adjacent forest. In Kelp Bay, where there was little trapping pressure during the study and few predators able to kill otters, the reasons for the otter's reluctance to cross those shallow sloped shores was not clear, especially since otters are probably able to to cross beaches more easily than steep, rocky intertidal areas.

The intertidal area that the otter would have to cross would only be exposed during the time when the tide is out. During the highest tides, there would be little difference in the distance from the edge of the water to the forest between high sloped and low sloped shores. Since there was no difference in the activity of otters in relation to tide (see: Activity), it does not seen plausible that exposure while crossing intertidal areas would have much impact on selection for or against resting areas in the forest.

An important consideration as to why otters used some areas and avoided others might be combinations of habitat characteristics. In general, convex shorelines in Kelp Bay were usually steep shores with solid bedrock or large rocks while shores of low slope and fine material usually occurred on concave beaches. There did not appear to be a predominance of any kind of shore slope or material for straight areas.

Because of the gradual uplift through time of the islands in southeastern Alaska (Selkregg, 1976), the areas above the steep shores are also usually steep (at least for a short distance into the forest). As shores have been lifted through time above the level of the water, soil, moss and eventually trees have covered the rock material. Large rocks in intertidal areas contain large amount of interstitial space. On close examination, solid bedrock areas contain many faults and fissures. The cracks and interstitial areas form natural cavities above the steep intertidal areas. Otters used many of these cavities along the shore of Kelp Bay for resting sites.

Areas above the shallow sloped beaches of sand, gravel or mud did not contain many natural burrows. The loose soil, shallow slope and high rainfall of the area would combine to make a poor area for burrows. There were few, if any, animals on Baranof Island that dig burrows, and otters normally do not dig the burrows they use (Liers 1951). In addition, streams were generally associated with these beaches, resulting in high water tables in the area of the stream bottom.

Probably no individual factor can be characterized as the most important reason why otters use areas near steep shores of solid or large rocks. More likely it is a combination of factors or features that those habitat types provide: Shelter close to shore, burrows that are dry or not likely to cave in and close to optimal feeding areas.

Denning habitat

Few detailed published reports of natal dens for river otters in North America are available, and none for Alaska. Liers (1951) described two dens in Minnesota in abandoned woodchuck (Marmota monax) holes and three in Florida. In Florida, one was in dry grass, one in a brush pile and one was beneath the roots of a tree. Melquist and Hornocker (1983) found one radio-equipped adult female using an abandoned fox (species not identified) den one year and a brush pile the next. Reid (1982) also found one radio-equipped female with young using an abandoned fox den in Alberta.

In Kelp Bay natal dens were located for three adult females (Nos. 78, 79 and 81) in spring 1982 and two females (Nos. 71 and 78) in spring 1983. The habitat characteristics of the den area used by each female otter is described below. The location of each den is shown in Figure 7.

Adult female No. 78

Female No. 78 was first located at the natal den area on May 6, 1982, and continued to use it until mid-July. This natal den area was approximately 0.8 km from shore at 100 m elevation. The forested slope was 21 to 40^{o} and generally northwest facing. The den itself was on a small forested knob near the edge of a shallow ravine 30 m from a steep stream. Forest habitat consisted of uneven-aged old-growth hemlock and cedar, with some Sitka spruce. Shrub cover was predominantly Vaccinium spp.and rusty menziesia. Crown closure was 21 to 40%, tree height 16 to 23 m and crown diameter 3 to 6 m. The forest around the den was surrounded on three sides by clear cut with the nearest cut

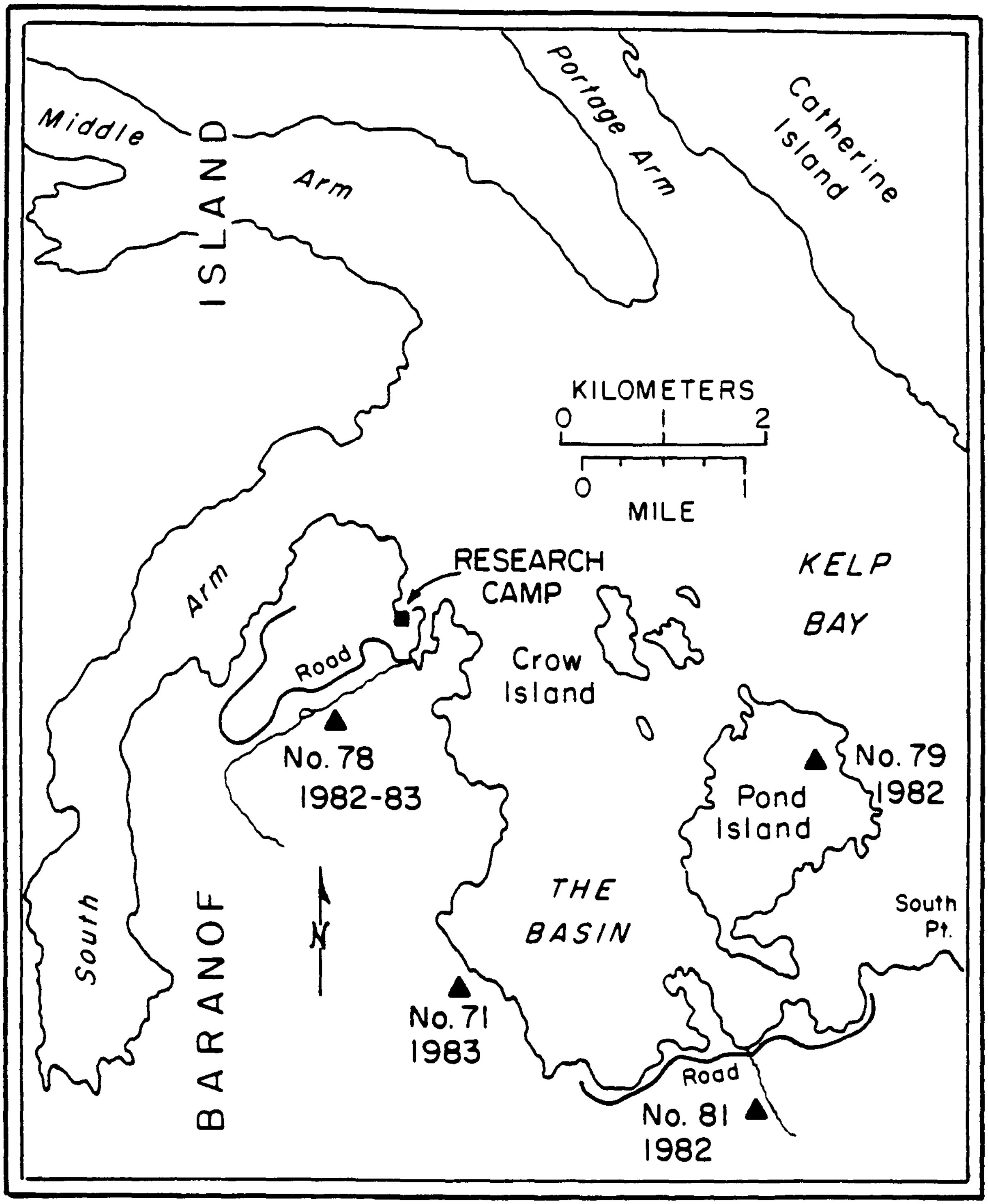

Figure 7. Locations of natal den areas used by radio-equipped adult female river otters at Kelp Bay, Alaska. Triangles indicate den areas.

area approximately 100 m from the den area. One abandoned logging road was 150 m uphill and another 300 m downhill from the den site. The lower road was adjacent to a stream which flowed to the ocean from a pond.

The den was beneath the mound formed by a rotted stump (termed a "stump mound"). It appeared that this type of mound probably resulted from the gradual decay of a snag (standing dead tree commonly occurring in undisturbed uneven-aged old-growth) and not from wind thrown trees or stumps resulting from logging. The mound was approximately 1.5 to 2 m in diameter, 1 m high, with several hemlocks (75 to 100 mm dbh) growing from it. One small entrance (approximately 200 to 250 mm diameter) was noted beneath the roots of the mound. No digging activity (fresh dirt) was noticed at the entrance during the first examination (May 15) or on subsequent visits to the den. Only a faint trail leading a short distance from the den was discernible.

Access to the den from the ocean was probably by following the stream to the bottom of the hill below the den, then up the hill. One m of snow covered the area during the first examination, but a single, well-used route from the stream to the den could not be found.

On one occasion (July 5) this female was followed up the stream and to the den area with the telemetry equipment. She was not visually observed during this period.

While No. 78 occupied the den and after she moved the pups to the shore, I found very little evidence of otter activity in the natal den area. There were no scats, scent posts or "rubbing areas" such as those found at frequently used sites along the shore.

Adult female No. 78 was not located at the natal den area after July 19 and probably moved the pups at that time. By July 19, she had localized at a site 1.25 km from the natal den. This site was on the shore of a cove into which the stream near the den flowed. The forest habitat of the shoreline site consisted of hemlock/spruce old-growth leave-strip. Crown closure was 21 to 40%, crown diameter was 7 to 12 m and tree height 24 to 30 m. The west facing forest slope was 21 to 40°. Several burrows were in the area and, unlike the natal den area, evidence of otter activity included worn trails and scats. This area was used until July 25.

The next area where No. 78 localized and apparently kept the pups was on the shore, near the entrance to the cove, 0.45 km from the initial shoreline site in the cove. This was an area of uneven-aged old-growth hemlock/spruce, with crown closure 21 to 40%, crown diameter 7 to 12 m and tree height 24 to 30 m. Numerous burrows, trails and scats were found in the area. By late July, yearling male No. 99 was frequently located with No. 78 or at the area where the pups were believed to be. Two pups were first observed with Nos. 78 and 99 on August 25.

In early September, Nos. 78 and 99 moved back into the cove and radio-locations indicated they localized near the mouth of a stream where pink salmon were spawning. Fish remains and otter tracks in the mud indicated that the otter were feeding on the salmon. Most of their radio-locations were at this area until mid-September, after which the otters moved throughout their home range and did not localize at any one site for more than a few days.

In May 1983, No. 78 returned to the 1982 natal den area, but used a burrow at the base of a live standing hemlock, about 100 to 150 m from the den used in 1982. The immediate area was similar to that of 1982, except the den site was 30 to 35 m from the clear cut and 60 to 80 m from the higher logging road. Subsequent to the date the den area was first examined (May 21) she moved to the den used in 1982 (Noll, in prep.). No snow covered the ground in this area in May 1983.

Adult female No. 79

This female was first located at the den area on May 6 and continued to use it until June 6. The den was on Pond Island, approximately 0.4 km from shore at less than 30 m above sea level. The den was located on a small (4 m high by 10 m diameter) hill surrounded by open muskeg. The vegetation on the hill and the area surrounding the muskeg was uneven-aged old-growth conifer forest. Hemlock and cedars were the predominant overstory trees with dense Vaccinium spp.and rusty menziesia shrub cover. Crown closure was 41 to 60% and tree height less than 15 m. No recent logging has occurred on Pond Island. A small stream flowed from the muskeg to the shore.

The den was beneath the mound formed by a rotted stump, similar to the den used by No. 78. This stump mound had two 300 mm dbh hemlocks growing from it. Several well-worn trails within 2 m of several entrances to the burrow system were noticed. No digging or other activity was noticable at the entrances to the den.

Access to the den area from the ocean was probably by following the stream to the muskeg, then one of several well worn animal trails leading to the general area of the small hill. The most direct route was blocked by several hills and a steep rock cliff near the shore. Similar to No. 78's den, there was very little evidence of No. 79's occupancy of the den.

After apparently leaving the den in early June, she used various burrows along the northeastern side of Pond Island. She did not appear to localize at any one site as she had in May.

Adult female No. 81.

Female No. 81 was first located at the natal den area on May 3 and continued to use it until mid-June. The den was 0.5 km from shore at approximately 210 m above sea level, on a northwest facing slope of 21 to 40°.

The major stream draining the area was about 100 m to the north. This stream flowed through an uneven-aged old-growth stand between two clear cut areas. An abandoned logging road followed the shoreline below the den area and the clear cuts and crossed the stream.

The forest habitat consisted of uneven-aged old-growth conifers, with scattered cedars (10 to 20% crown closure) predominating in the immediate area. Tree height was 9 to 12 m and crown diameter less than 3 m. <u>Vaccinium</u> spp. and rusty menziesia occurred beneath the patches of trees. During the initial examination (May 18) more than 1 m of snow covered the area, but subsequent visits after snow melt revealed the areas between the patches of cedar were wet and muskeg-like.

The den was similar to those used by Nos. 78 and 79. It too was beneath a stump mound about 1 m high and 2 m in diameter, with several 250 to 300 mm dbh cedars growing from the mound. A well-worn trail in the snow near the mound led to a 250 mm opening to the burrow. Again, similar to 78 and 79's dens, no evidence of digging activity was noticed during the initial or subsequent visits to the den.

Access to the den area was probably at least part way up the stream (the most direct route), but between the den and the shore were several very steep areas in the stream. No single route from the stream to the den area was evident, though otter tracks in the snow from the direction of the stream converged at the trail near the den site.

On June 25, female No. 81 was located in a den approximately 150 m downhill from the original site. She continued to use this new area until at least July 15. This den was located on a small knob about 3 m above a small creek. The vegetation of the generally northwest facing 21 to 40^{o} slope consisted of uneven-aged old-growth conifers, predominantly cedars with a heavy shrub cover of Vaccinium spp. and rusty menziesia. Again, the den was beneath a rotted stump mound. Several cedars (300 to 400 mm dbh) grew from the mound. A small (100 to 150 mm diameter) hole was the only entrance to the burrow noticed. No digging or any other evidence of activity in the area was noticable, except for a short (less than 1 m) trail leading to the burrow entrance. The small stream near the second den site drained into the larger stream near the natal den area.

The last radio-location for No. 81 at either of the above described areas was on July 15. She then localized at an area 1.0 km from the dens on a narrow (1 km long by 0.25 km wide) peninsula. Forest habitat was uneven-aged old-growth of spruce/hemlock or hemlock/cedar, crown closure 41 to 60%, tree height 16 to 30 m and crown diameter 3 to 10 m. Most of the radio-locations of the otters in this area were 30 to 100 m from shore and none of the land on the peninsula rose to more than 10 m above sea level.

On August 6, female pup No. 70 was captured in the area being used by No. 81, and on August 19, two pups, Nos. 76 and 95 were captured nearby. The radio-equipped otters continued to use the middle portion of the peninsula until August 30. From then until September 27, most of the locations indicated they remained at an area on the end of the peninsula. This area was mostly uneven-aged old-growth hemlock, 24 to 30 m tree height with variable crown closure. Part of the area used by the otters was a patch of wind thrown timber with heavy <u>Vaccinium</u> spp. and rusty menziesia shrub cover. Most of the blown over trees were suspended above the ground, allowing more freedom of movement for the otters than for the research personnel. Numerous trails and scat piles were observed beneath these interlocked trees.

By late September, the three radio-equipped otter pups and No. 81 traveled as a family group throughout No. 81's formerly used home range, and did not appear to localize at one site for more than a few days.

Adult female No. 71.

In May 1983, this female was located in a burrow on the top of a ridge, just above a steep rock face, about 0.25 km from shore at 150 m above sea level. The slope below the den was 61 to 90°. The slope of the area inland of the den was 0 to 20° and faced northeast. The nearest accessible freshwater would have been either a very small steep stream (within 100 m) or a muskeg area (approximately 0.4 km away) which drained to the shore. Forest habitat of the area was uneven-aged old-growth. Predominant trees were hemlock and Sitka spruce, tree height was 22 to 30 m, crown closure was 41 to 60% and crown diameter was 6 to 9 m. Dense Vaccinium spp. and rusty menziesia formed the shrub layer. No logging had occurred near this area.

The den itself was in a burrow beneath the rocks of an outcropping at the top of the steep rock face. The immediate area around the opening to the burrow seemed to show more evidence of activity than the other dens examined (i.e. some digging and scratching in the moss). Nevertheless it still showed less activity than frequently used areas along the shore. No scats or scent posts were found.

The route of access to the den was unknown. The most direct route would probably have been impossible because of the steep rock face. The nearest small stream was also very steep. In several places the water ran over near vertical rock out-croppings. J. Noll (pers. comm.) reported locating this female in the area of the muskeg and the stream draining the muskeg shortly before she localized at the den site. This would have made a reasonable route of access and the distance would have been comparable to that traveled by female No. 78.

Perhaps one of the more interesting aspects shared by each of the natal den areas used by the radio-equipped otters was the distance from the shore. Numerous burrows occurred all along the shore in the home ranges of each of these females, but in each case, the otter denned at least 250 m from shore. One of the dens described by Liers (1951) was about 150 m from water and about 50 m above high water mark. When the pups were eight weeks old, the female moved the pups 0.8 km to a pond. Another den described by Liers was about 165 m above the high water mark. The adult female studied by Melquist and Hornocker (1983) in Idaho used a den only 4 m above high water on an old stream bed. The next year she used a brush pile in an area flooded by beavers. Reid (1982) in Alberta, described an adult female's natal den as about 3 m above a muskeg area, but 250 m from permanent water.

In all of the reports noted above, the females and young moved from the natal den area to feeding or other activity areas between 5 and 12 weeks after parturition. At Kelp Bay, once a female and young left the natal den area, no radio-locations indicated that they returned to the den areas (except No. 78 in spring 1983).

Another feature shared by each of the dens at Kelp Bay, except No. 71's, was that the natal dens were located beneath stump mounds in stands of low volume timber surrounded by more productive stands. Animals such as foxes, coyotes (Canis latrans) and woodchucks which dug the natal dens reported used by otters in other areas (Liers 1951, Melquist and Hornocker 1983 and Reid 1982) are not present on Baranof Island. Many ground cavities occur throughout the forest, probably a result of shallow soils, large trees and heavy moss ground cover. One way that cavities can form is that conifers in the area commonly sprout in the moss covering downed trees or stumps (Franklin et al. 1981). In time, the small trees extend roots down to the ground as the log or stump rots away beneath it, eventually giving the tree a "cypress-like" appearance. Eventually the base of the tree is covered with moss and the old log or stump rots away, leaving a cavity beneath the tree. As a forest matures, the older trees that are not wind-thrown become snags and eventually rot to the ground, forming mounds.

None of the natal den areas found at Kelp Bay showed evidence of being occupied by the otters. In most instances, all that was evident was a short trail at the entrance to the burrow. The only way to determine that a radio-equipped otter was inside the burrow was by using the telemety equipment. After the females left the den areas in summer 1982, all the sites were re-examined. Without previous knowledge that the otters had occupied the areas, it would have been difficult to determine that any otter activity had occurred there. Melquist and Hornocker (1983) commented on the lack of sign at the natal dens examined.

The areas used as natal dens were not near areas with sufficient food for the otters. The females had to travel from the dens to the feeding areas until the pups were old enough to move closer to the ocean shore.

One question that should be considered is why the females chose areas for dens that were so far from shore, when the greatest proportion of locations and sites used throughout the rest of the year was along the shore. Perhaps one reason dens were away from the shore was because the breeding season occurred just after parturition. Liers (1951) reported that adult males actively searched for receptive females during the breeding season. It is unknown what adult males might do to a litter of newborn pups, but if the den were along the shore, in areas frequently visited by other otters, males would likely come upon a nest of young.

Predator avoidance might be another part of the strategy of placing the pups away from the shore. While very few of the carnivores present in other areas where otter occur inhabit Baranof Island, mink or marten might enter an otter natal den and could possibly kill the pups. The shoreline is actively used by most of the terrestrial animals present on Baranof Island.

Further evidence that suggests pups are secreted away from some possible danger was the absence of scat or scent posts in the vicinity of the dens. The use of streams to travel to and from the dens may have also served to prevent other otters or predators from following the females to the dens.

The effect that clear cut logging would have on the use of an area by otters for natal dens is not certain. It is evident that the habitat characteristics would be drastically changed. Cutting would probably more adversely impact natal den areas than otters' use of shore areas where strips of old-growth are usually retained between the shore and the clear cut. The changes in habitat characteristics that could occur after logging would include removal of the canopy and deposition of large amounts of slash and debris on the forest floor.

The increased shrub cover resulting from the opened canopy following logging might not greatly affect the use of a den area. Most of the natal dens and areas used by the family groups after moving from the den exhibited a large amount of shrub cover. Short term use of the den might be affected more by the mechanical disturbances occurring during logging operations. Long term effects of clear cutting might include increased siltation or soil mass wasting which could fill the burrows used as natal dens. The slash and debris on the ground resulting from clear cutting (appropriately labeled by Larsen (1983) as a "formidable vegetative labyrinth") would hinder otters traveling through the area.

An important consideration of the effects of logging on otter denning would be whether logging occurred during spring and summer when pups are in the den. Because natal dens are hard to identify, determining if an otter were denning in an area being logged would be virtually impossible without the aid of radio-telemetry equipment.

SUMMARY

Habitat use was determined for river otters instrumented with radio transmitters in Kelp Bay. Over 75% of the radio-locations used to determine habitat use indicated the otters were within 30 m of shore. Seventy four percent of the specific sites used by river otters were within 30 m of shore. The only substantial use of areas farther inland by radio-equipped otters was by three adult females during the denning season and by one adult male that spent most of the summer in a river system. Otters using only inland areas did not appear to be present in the Kelp Bay area. River otters at Kelp Bay used terrestrial habitat in proximity to water similar to that determined in other studies.

The predominant terrestrial habitat types in the area of Kelp Bay were uneven-aged old-growth stands of hemlock and mixed hemlock/spruce. Most of the radio-locations of otters and the sites used by radio-equipped otters were in those vegetation and forest types. No radio-locations of otters or sites used by radio-equipped otters occurred in clear cuts. Otters did use uneven-aged old-growth leave-strips between the shore and clear cuts. Logging away from the shore probably did not greatly affect the otters' use of shorelines. Forest undergrowth in use areas was frequently absent, probably a result of long-term use by otters.

Radio-locations of otters and the sites used by otters occurred more frequently adjacent to convex than concave shore. Analysis of the slope and materials of shore areas indicated that at radio-locations, the otters were found more often than expected adjacent to areas of 41 to 60°/solid rock, 61 to 90°/solid rock and 41 to 60°/large rocks. The otters were found less often than expected near areas of 0 to 20°/solid rock, 0 to 20°/large rocks, 0 to 20°/fines and 0 to 20°/mixed. The radio-equipped otters used sites adjacent to shore of 0 to 20°/fines less often than expected. The preference shown by otters for areas adjacent to steep shores of solid or large rock on convex shorelines was probably related to availability of food and cover.

Natal dens of four adult female river otters were located 0.8, 0.5, 0.4, and 0.25 km from shore, at elevations up to 210 m, and all were in uneven-aged old-growth forest. Three dens were in burrows beneath rotted stump mounds and one was in a natural cavity beneath rocks and soil. Three dens were located near streams or muskegs and the routes of access to those dens were probably up the streams. Very little sign or evidence of use by otters was present at any of the natal den areas in 1982 or 1983. Habitat characteristics of natal den areas would probably be drastically changed by clear cutting.

The radio-equipped adult female otters left the natal den areas in June and July. They then remained along the shore at various sites. Soon after moving to the shoreline, pups were observed with the females.

CONCLUSIONS

1. Adult river otters in southeastern Alaska are one of the larger forms of river otters in North America. Permanent canines of the otter pups appeared to be fully emerged by October.

2. River otters in the Kelp Bay area were born in early May and the adult females bred soon after parturition. Pups remained at natal den areas until late June or mid-July. After leaving, the pups traveled with the family group through most of the fall. Otter family groups consisted of adult females, pups of the year and adult-sized otters of unknown age or sex. In the areas used by the radio-equipped family groups, a minimum of 18 otters used 21.4 km of marine shore (1 otter per 1.18 km).

3. One adult male was occasionally observed traveling with groups of adult-sized otters of unknown age or sex. The relationship of adult male otters to the family groups is not known.

4. Home range used by radio-equipped otters in Kelp Bay was considered to be the length of coastal shoreline used. The home range used by an adult male varied from 22.5 km of shore during spring to 1.0 km in the fall. Four radio-equipped family groups of otters showed little variation in seasonal home range lengths and used 4.1, 5.4, 11.3 and

2.9 km of shoreline throughout the entire period that each family group was monitored. Radio-equipped family groups used adjacent but essentially non-overlapping shoreline. The respective home range used by each family group remained the same throughout all seasons. The adult male used different areas in Kelp Bay in different seasons.

5. Most otter movements involved traveling in the water close to shore. There were no apparent seasonal patterns of movements between consecutive-day radio-locations for all of the radio-equipped otters. Distances moved between same-day radio-locations appeared to be greater during the denning season than after the denning season for the adult female otters with pups.

6. Otters were commonly observed foraging in the water throughout the day, and no preference for particular tidal phases or stages could be determined. When located, radio-equipped otters were most active in winter and least active in summer.

7. Habitat use was determined for 11 river otters in Kelp Bay. Over 75% of the radio-locations when otters were on land indicated they were within 30 m of shore. The only substantial use of inland areas was by adult females at natal den areas, and by one adult male that remained in a river system for much of the summer.

8. The predominant terrestrial habitat at Kelp Bay was uneven-aged

old-growth hemlock and hemlock/spruce. Most of the radio-locations of otters and sites used by otters were in uneven-aged old-growth. Retention of uneven-aged old-growth leave-strips provided otter habitat between the shore and clearcuts. Clear cutting away from the shore probably did not greatly affect otter use of shorelines.

9. Radio-locations and sites used by river otters frequently occurred along convex shores. Otters appeared to select areas adjacent to shores consisting of solid or large rock with 41 to 60° or 61 to 90° shore slope. Otters were found less often than expected adjacent to shores with 0 to 20° slope. These preferences were probably related to food and cover availability

10. Natal dens of four adult female otters were located. All natal dens examined were greater than 0.25 km from shore and occurred in uneven-aged old-growth forests. Three dens were in burrows beneath rotted stumps and one was in a cavity beneath rocks and soil. One adult female used the same natal den area in spring 1982 and 1983. Very little evidence of otter occupancy was found near the natal dens. Habitat characteristics of natal den areas would be greatly altered by clear cutting.

MANAGEMENT RECOMMENDATIONS

1. River otters at Kelp Bay, Baranof Island, used a narrow strip of mature forest along the coastal shore. Uneven-aged old-growth conifer leave-strips between the shore and clear cuts were also used. I recommend leaving a strip of uncut forest no less than 50 to 75 m between the shore and future clear cuts. Leave-strip width should be greater in areas vulnerable to wind-throw.

2. Otters preferred the forest adjacent to steep shores consisting of solid bedrock and large rocks. Retain these areas from road building or activities associated with logging.

3. Natal den areas occurred more than 0.25 km inland and were associated with drainages. Retain the forest along water courses from clear cutting to allow habitat for the natal dens and access to the den areas.

4. Female river otters begin denning in early May at Kelp Bay, in southeastern Alaska. I recommend logging activities not take place in areas adjacent to drainages until late summer.

5. If habitat classification systems for the Forest Service are to be used for management purposes that include more than just timber harvest, the special features of the forest along the shore must be taken into account.

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APPENDIX A. Monthly temperatures (^{o}C) recorded at Kelp Bay, Alaska. 1982.

Month	Range	Average daily minimum	Average daily maximum	Monthly average
January	------------Not Available------------			
February	-12/+ 4	- 6.9	- 1.2	- 3.8
March	- 6/+ 7	- 2.0	+ 2.9	+ 0.5
April	- 5/+ 7	- 0.7	+ 5.0	+ 2.2
May	0/+15	+ 2.3	+ 8.5	+ 5.2
June	+ 4/+20	+ 7.5	+15.4	+11.4
July	+ 7/+21	+10.3	+16.6	+13.4
August	+ 7/+18	+ 8.8	+14.5	+11.3
September	+ 3/+18	+ 7.4	+13.4	+10.4
October	0/+13	+ 3.5	+11.1	+ 5.9
November	- 7/+ 7	- 2.1	+ 2.6	+ 0.4
December	- 3/+ 7	- 0.2	+ 2.7	+ 1.3

APPENDIX B. Rainfall[a] (mm) recorded at Hidden Falls Hatchery, Kasnyku Bay, Baranof Island, Alaska. (Latitude 57° 13' N., Longitude 134° 52' W.) Approximately 13 km southeast of Kelp Bay. Recorded by the ADFG, FRED Division. (unpublished records).

Month	1980	1981	1982
January	—	660	—[b]
February	—	156	—[b]
March	—	437	100
April	—	105	373
May	64[c]	99	239
June	51	91	0
July	75	82	129
August	88	194	78
September	362	500	114
October	513	262	482
November	746	663	282
December	40	393	267

[a]Rainfall recorded should be considered minimum amount of precipitation as it may not accurately reflect amount due to snowfall.
[b]Unavailable
[c]Rain guage installed in mid-May, 1980.

APPENDIX C. Snow depth (m) recorded at four different sites near research camp at Kelp Bay, Alaska. 1982.

	Open beach, above tide line	Uneven-aged old-growth conifer forest[a]	Clear cut (edge)	Clear cut (75 m from edge)
February 20	1.14	0.76	1.53	1.70
March 6	0.91	0.68	1.27	1.59
March 19	0.89	0.64	1.10	1.40
March 27	0.84	0.54	0.94	1.29
April 6	0.77	0.51	0.76	1.07
April 18	0.99	0.46	0.79	1.12
May 1	0.63	0.26	0.36	0.74
May 5	—[b]	—[c]	—[c]	—[c]

[a]30 to 100 from shore
[b]Not measurable
[c]Not measured

APPENDIX D. Classifications of habitat characteristics recorded for radio-locations of otters and sites used by radio-equipped river otters, Kelp Bay, Alaska.

Distance from shore: within 30 m
30 to 100 m
100 to 400 m
greater than 400 m
other[a]

Forest characteristics

Vegetation type: uneven-aged old-growth
clear cut
leave-strip
conifer regrowth
muskeg
tidal flat
other[a]

Species: hemlock
spruce
cedar
mixed conifer/decidous
alders
grass
other[a]

[a]Includes those not easily classified into the above categories.

APPENDIX E. Classifications of habitat characteristics recorded at use areas for radio-equipped river otters, Kelp Bay, Alaska.

Distance from shore:

- with 30 m
- 30 to 100 m
- 100 to 400 m
- greater than 400 m
- other[a]

Shore configuration:

- convex
- concave
- straight
- offshore rocks
- other[a]

Forest characteristics

Vegetation types:

- uneven-aged old-growth
- clear cut
- leave-strip
- conifer regrowth
- muskeg
- tidal flat
- other[a]

Species:

- hemlock
- spruce
- mixed conifer/deciduous
- alders
- grass
- other[a]

Crown closure:

- 0 to 20%
- 21 to 40%
- 41 to 60%
- 61 to 80%
- 81 to 100%

Tree height:

- less than 15 m
- 16 to 23 m
- 24 to 30 m
- greater than 30 m

Crown diameter:

- 3 to 6 m
- 7 to 12 m
- greater than 13 m

[a]Includes those not easily identified by the above catagories.

APPENDIX F. Classifications of shore characteristics recorded at radio-locations of otters and sites used by radio-equipped river otters, Kelp Bay, Alaska. Characteristics recorded only for those radio-locations and sites within 30 m of shore.

Shore configuration:	Shore slope:
convex	0 to 20°
concave	21 to 40°
straight	41 to 60°
offshore rocks	61 to 90°
other[a]	variable

Shore material:

solid rock	- continuous or almost continuous bedrock
large rock	- greater than 300 mm diameter
medium rock	- 200 mm to 300 mm diameter
small rock	- gravel to 200 mm diameter
gravel	
sand	
mudflat	
mixed	- no predominant material

[a]Includes those not easily identified by the above catagories.

APPENDIX G. Comparisons (t test, 0.05 significance level) between seasons of straight-line distances between same-day radio-locations of radio-equipped river otter, Kelp Bay, Alaska. Dashed lines separate family groups.

Otter No.	Seasons	df	Critical t	Probability	Result
Male 99	Spring - Summer	78	0.837	0.20 < P < 0.50	no sign. diff.
	Spring - Fall	134	0.388	P > 0.50	no sign. diff.
	Spring - Winter	82	0.882	0.20 < P < 0.50	no sign. diff.
	Summer - Fall	173	-2.251	0.01 < P < 0.025	Summer < Fall
	Summer - Winter	120	0.913	0.20 < P < 0.50	no sign. diff.
	Fall - Winter	61	1.464	0.10 < P < 0.20	no sign. diff.
Ad. fem. 78	Spring - Summer	63	2.493	0.005 < P < 0.01	Spring > Summer
	Spring - Fall	63	2.167	0.01 < P < 0.025	Spring > Fall
	Spring - Winter	10	2.117	0.05 < P < 0.10	no sign. diff.
	Summer - Fall	114	-0.600	P > 0.50	no sign. diff.
	Summer - Winter	61	0.930	0.20 < P < 0.50	no sign. diff.
	Fall - Winter	61	1.144	0.20 < P < 0.50	no sign. diff.
	Denning- before	(insufficient same-day locations before Denning)			
	Denning- after	23	2.610	0.005 < P < 0.01	Denning> after
- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
Ad. fem. 71	Summer - Fall	30	-0.861	0.20 < P < 0.50	no sign. diff.
	Summer - Winter	2	-0.800	P > 0.50	no sign. diff.
	Fall - Winter	2	-0.522	P > 0.50	no sign. diff.
Fem. pup 91	Fall - Winter	12	1.614	0.10 < P < 0.20	no sign. diff.
- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
Ad. fem. 81	Spring - Summer	66	1.157	0.10 < P < 0.20	no sign. diff.
	Spring - Fall	18	1.540	0.10 < P < 0.20	no sign. diff.
	Spring - Winter		(no same-day locations during Winter)		
	Summer - Fall	18	0.803	0.20 < P < 0.50	no sign. diff.
	Summer - Winter		(no same-day locations during Winter)		
	Fall - Winter		(no same-day locations during Winter)		
	Denning- before	57	0.124	P < 0.50	no sign. diff.
	Denning- after	27	2.334	0.01 < P < 0.025	Denning> after
Fem. pup 70	Summer - Fall	24	-1.060	0.20 < P < 0.50	no sign. diff.
	Summer - Winter	(insufficient same-day locations during Winter)			
	Fall - Winter	(insufficient same-dau locations during Winter)			
Fem. pup 76	Summer - Fall	24	-0.641	P > 0.50	no sign. diff.
	Summer - Winter	(insufficient same-day locations during Winter)			
	Fall - Winter	(insufficient same-day locations during Winter)			

APPENDIX G. (cont.)

Otter No.	Seasons	df	Critical t	Probability	Result
Male pup 95	Summer - Fall	23	-0.385	P > 0.50	no sign. diff.
	Summer - Winter	(insufficient same-day locations during Winter)			
	Fall - Winter	(insufficient same-day locations during Winter)			
Ad. fem. 79	Spring - Summer	51	0.843	0.20 < P < 0.50	no sign. diff.
	Spring - Fall	12	3.932	0.005 < P < 0.001	Spring > Fall
	Spring - Winter	(insufficient same-day locations during Winter)			
	Summer - Fall	12	2.822	0.005 < P < 0.001	Summer > Fall
	Summer - Winter	(insufficient same-day locations during Winter)			
	Fall - Winter	(insufficient same-day locations during Winter)			
	Denning- before	5	4.173	0.0025< P < 0.005	Denning> before
	Denning- after	58	3.507	P < 0.0005	Denning> after

APPENDIX H. Comparisons (t test, 0.05 significance level) between radio-equipped otters of the straight-line distances between same-day radio-locations, Kelp Bay, Alaska.

Otter Nos.	Seasons	df	Critical t	Probability	Results
No. 78 - 81	Sprg/Sum/Fall	86	0.202	P > 0.50	no sign. diff.
78 - 79	Sprg/Sum/Fall	65	2.225	0.01 < P < 0.025	78 > 79
81 - 79	Sprg/Sum/Fall	65	2.621	0.005 < P < 0.025	81 > 79
99 - 79	Sprg/Sum/Fall	318	1.278	0.20 < P < 0.50	no sign. diff.
99 - 81	Sprg/Sum/Fall	86	-1.918	0.05 < P < 0.10	no sign. diff.
74 - 78	Spring	11	-0.340	P > 0.50	no sign. diff.
74 - 79	Spring	5	0.682	P > 0.50	no sign. diff.
74 - 81	Spring	25	-0.066	P > 0.50	no sign. diff.
74 - 99	Spring	5	0.765	0.20 < P < 0.50	no sign. diff.
99 - 79	Spring	96	0.397	P > 0.50	no sign. diff.
99 - 81	Spring	20	-1.660	0.10 < P < 0.20	no sign. diff.

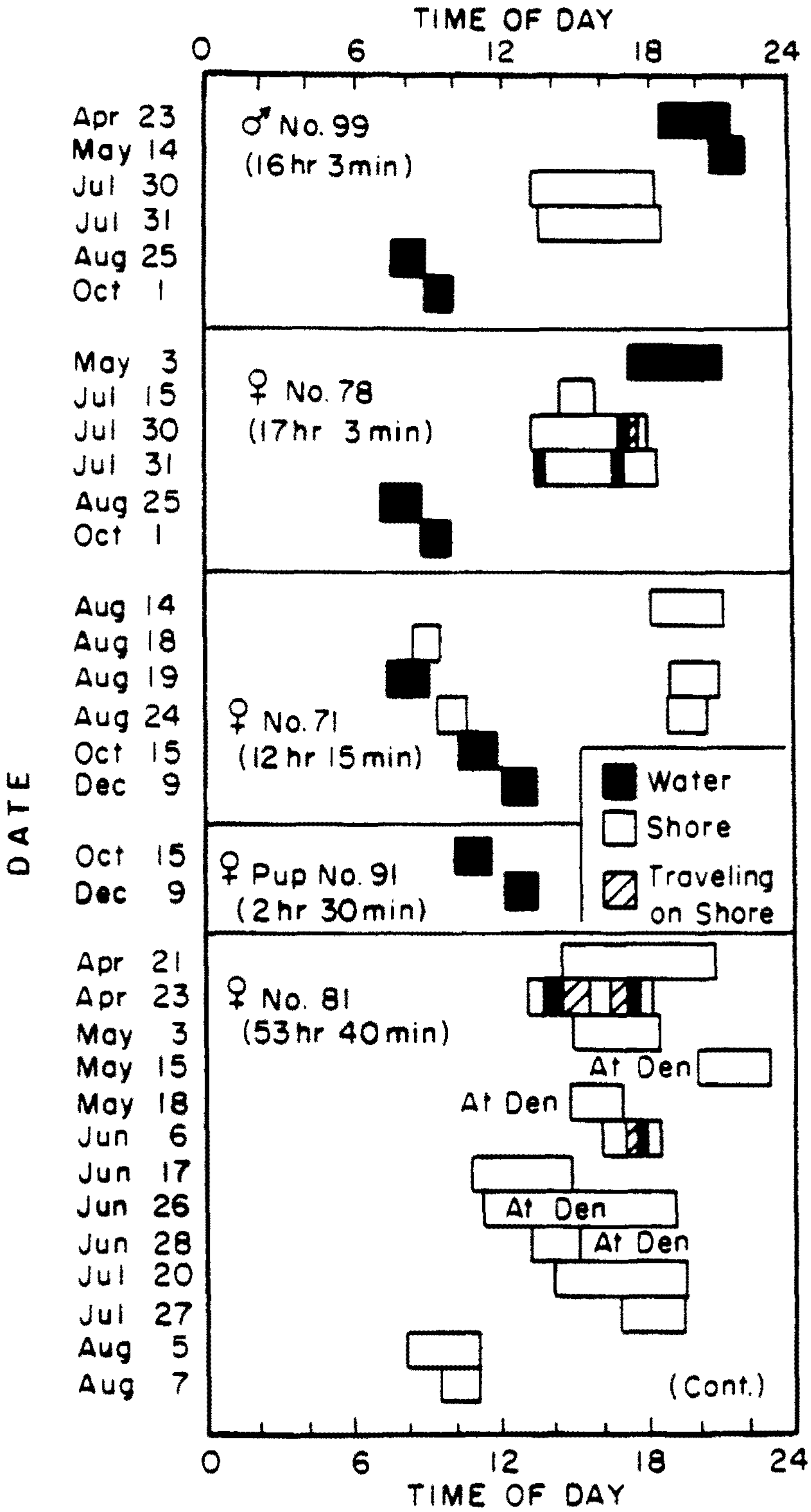
APPENDIX I. Comparisons (t test, 0.05 significance level) between seasons of straight-line distances between consecutive-day radio-locations of radio-equipped river otter, Kelp Bay, Alaska. Dashed lines separate family groups.

Otter No.	Seasons	df	Critical t	Probability	Results
Male 99	Spring - Summer	63	-0.651	P > 0.50	no sign. diff.
	Spring - Fall	107	6.294	P < 0.001	Spring < Fall
	Spring - Winter	8	-1.652	0.10 < P < 0.20	no sign. diff.
	Summer - Fall	44	-2.439	0.005 < P < 0.01	Summer < Fall
	Summer - Winter	8	-1.503	0.10 < P < 0.20	no sign. diff.
	Fall - Winter	52	-0.797	0.20 < P < 0.50	no sign. diff.
Ad. fem. 78	Spring - Summer	71	-0.519	P > 0.50	no sign. diff.
	Spring - Fall	59	-1.258	0.20 < P < 0.50	no sign. diff.
	Spring - Winter	28	-0.859	0.20 < P < 0.50	no sign. diff.
	Summer - Fall	100	-1.327	0.01 < P < 0.20	no sign. diff.
	Summer - Winter	13	-0.672	P > 0.50	no sign. diff.
	Fall - Winter	57	0.0	P > 0.50	no sign. diff.
	Denning- before	6	3.935	0.0025< P < 0.005	Denning> before
	Denning- after	122	1.430	0.10 < P < 0.20	no sign. diff.
- - -	- - -	- - -	- - -	- - -	- - -
Ad. fem. 71	Summer - Fall	54	-2.663	0.005 < P < 0.01	Summer < Fall
	Summer - Winter	24	-2.250	0.01 < P < 0.025	Summer < Winter
	Fall - Winter	46	-0.105	P > 0.50	no sign. diff.
Fem. pup 91	Fall - Winter	24	-1.097	0.20 < P < 0.50	no sign. diff.
- - -	- - -	- - -	- - -	- - -	- - -
Ad. fem. 81	Spring - Summer	36	2.993	0.0025< P < 0.005	Spring > Summer
	Spring - Fall	36	-0.418	P > 0.50	no sign. diff.
	Spring - Winter	10	1.243	0.20 < P < 0.50	no sign. diff.
	Summer - Fall	106	-5.040	P < 0.005	Summer < Fall
	Summer - Winter	79	-0.834	0.20 < P < 0.50	no sign. diff.
	Fall - Winter	47	1.075	0.20 < P < 0.50	no sign. diff.
	Denning- before	18	-2.501	0.01 < P < 0.025	Denning< before
	Denning- after	135	-1.264	0.20 < P < 0.50	no sign. diff.
Fem. pup 70	Summer - Fall	41	-2.033	0.01 < P < 0.025	Summer < Fall
	Summer - Winter	12	-2.218	0.01 < P < 0.025	Summer < Winter
	Fall - Winter	45	0.544	P > 0.50	no sign. diff.
Fem. pup 76	Summer - Fall	41	-2.160	0.01 < P < 0.025	Summer < Fall
	Summer - Winter	14	-0.787	0.20 < P < 0.50	no sign. diff.
	Fall - Winter	47	1.444	0.10 < P < 0.20	no sign. diff.

APPENDIX I. (cont.)

Otter No.	Seasons	df	Critical t	Probability	Results
Male pup 95	Summer - Fall	41	-2.295	0.01 < P < 0.025	Summer < Fall
	Summer - Winter	10	-1.036	0.20 < P < 0.50	no sign. diff.
	Fall - Winter	43	1.815	0.05 < P < 0.10	no sign. diff.
Ad. fem. 79	Spring - Summer	95	-1.740	0.05 < P < 0.10	no sign. diff.
	Spring - Fall	27	2.216	0.01 < P < 0.025	Spring > Fall
	Spring - Winter	4	-1.400	0.20 < P < 0.50	no sign. diff.
	Summer - Fall	27	4.407	P < 0.005	Summer > Fall
	Summer - Winter	65	-1.802	0.05 < P < 0.10	no sign. diff.
	Fall - Winter	4	-2.355	0.05 < P < 0.10	no sign. diff.
	Denning- before	39	1.415	0.10 < P < 0.20	no sign. diff.
	Denning- after	109	0.499	P > 0.50	no.sign. diff.
Ad. Male 74	Spring - Summer	17	3.747	0.005 < P < 0.001	Spring > Summer

Appendix J. Continuous monitoring periods for radio-equipped river otters, Kelp Bay, Alaska.



Appendix J. (cont.)