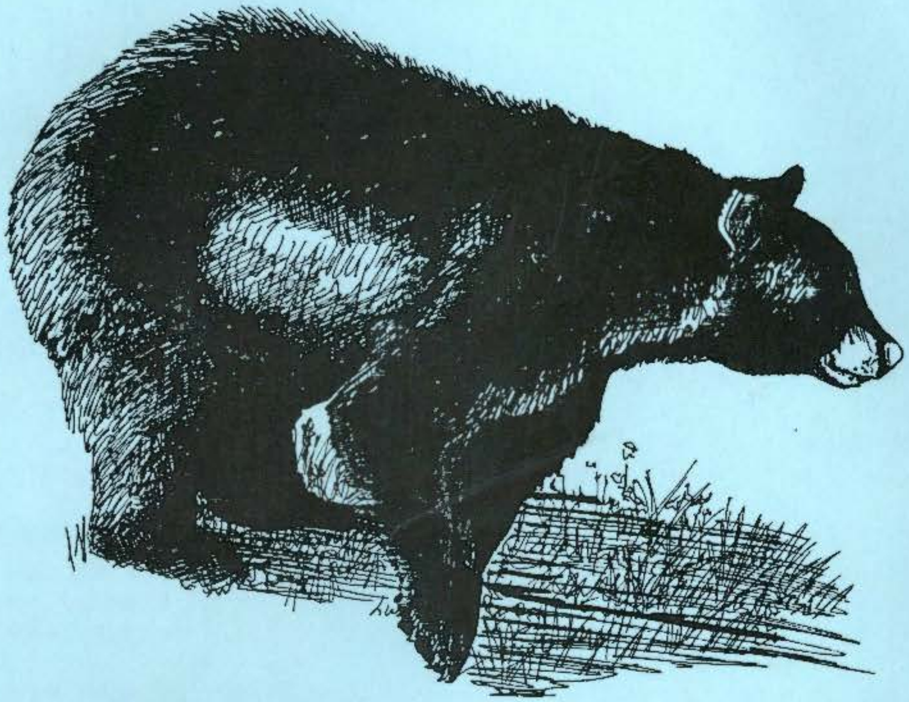
ALASKA DEPARTMENT OF FISH AND GAME
JUNEAU, ALASKA

BLACK BEAR MOVEMENTS AND HOME RANGE STUDY



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Final Report
Federal Aid in Wildlife Restoration
Projects W-17-10, W-17-11, W-21-1, and W-21-2, Job 17.2R

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JOB FINAL REPORT (RESEARCH)

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Project Nos.: W-17-10, W-17-11, W-21-1, W-21-2   Project Title: Big Game Investigations

Job No.: 17.2R   Job Title: Black Bear Movements and Home Range Study

Period Covered: July 1, 1977 through June 30, 1981

SUMMARY

Population identity, density, habitat use, sex and age composition, vulnerability to hunting and behavior of black bears were studied from 1976-1980 in northwestern Prince William Sound, Southcentral Alaska. The study was based on field observations and information obtained from 60 bears live-captured while testing foot snare, barrel-type live trap, and helicopter sampling techniques. Thirty of the 41 different individual bears captured were collared with radio transmitters and radio-relocated with fixed-wing aircraft.

Data indicated that individual bears moved freely within the study area despite large bodies of saltwater, large glaciers, and extensive snowfields; liberal flow of individual bears and genes probably occurred throughout the area.

Males were found to range over much larger areas than females. Both sexes exhibited communal use of portions of ranges. Estimated densities approached the greatest reported for areas in the contiguous United States.

Sex and age composition of the samples of bears obtained in spring with a helicopter most closely represented the hypothetical composition for the live population. Types of access available to hunters, methods of hunting, hunter selectivity, and differential behavior between sexes of bears, in combination, greatly biased hunter-killed spring samples toward adult males.

The live population was believed to be composed predominantly of females (many over 10 years of age) and $\leq$ 6-year-old males.

Sampling, in summer, along streams containing spawning salmon was unpredictable and yielded biased samples; few adult male bears were captured, bears were not always found to gather at the same streams each year, and in some years, few bears gathered at any stream to feed on salmon. Behavior of bears appeared to indicate preference to feed on berries rather than salmon.

Differences in behavior between sexes of bears indicated that males and females selected different habitats in spring. Circumstantial evidence indicated that bears were mobile, opportunistic feeders and selected diets high in protein and low in structural carbohydrates in the spring and diets high in nonstructural carbohydrates or fats in late summer and fall. Bears appear to eat large quantities of food and process it relatively inefficiently. Movement patterns were related to habitat use, feeding strategy, and reproductive behavior.

Recommendations were made for additional research to study movement patterns of adult males, to determine minimum sex ratios required for optimum productivity, and to determine the effects of sex and age hunter kill selectivity on genetic variability and long-term population stability.

Key words: Alaska, black bear, home range, movements.

CONTENTS

BACKGROUND

Widely distributed and apparently abundant, black bears (Ursus americanus) provide a full spectrum of recreational opportunities for people throughout most of Alaska. Statewide hunter harvest data and personal communications indicate that the black bear is rapidly becoming an important "primary" game species, in addition to being a "secondary" species taken incidentally to the harvest of other game animals. A recent increase in hunter harvest can be attributed, in part, to a greater number of hunters, short open seasons and permit hunts for other big game species, promotional efforts of guides or air taxi operators, and perhaps the realization by many hunters that black bears provide aesthetically pleasing hunts, a respectable trophy, and very flavorful meat.

Although recreational use of black bears has greatly increased in recent years, present knowledge about the biology and population ecology of this species in Alaska is still somewhat limited. Noteworthy published materials on black bears in Alaska include studies by Rausch (1961) on dentition and growth, Erickson (1965) on general life history, Hatler (1967 and 1972) on food habits, McIlroy (1970 and 1972) on ecology and hunter harvest, Frame (1974) on predation of salmon, Modafferi (1978a) on management techniques, and Schwartz and Franzmann (1980) on predation of moose. A program for sealing the hide and skull of black bears killed by hunters, initiated in many Game Management Units in July 1973 by the State of Alaska Department of Fish and Game, provides data on characteristics of the hunter harvest and the individual bears harvested.

Human interaction with black bears and encroachment onto their habitat is increasing throughout the State, but presently the degree of human influence on this species in Prince William Sound is unparalleled elsewhere. Recent upsurgence in recreational boating and kayaking, orginating primarily from the ports of Whittier and Valdez, has lead to an increase in the magnitude of direct interaction between humans and black bears throughout northern and western Prince William Sound. This general increase in human activity secondarily resulted in greater use of U.S. Forest Service public recreational cabins available in Prince William Sound and will in the future foster construction of additional overnight facilities. Recreational cabin facilities localize and intensify the potential for human interaction with bears and usurp a portion of bear habitat; location for cabin site selections should be critically scrutinized.

Increased hunting pressure and harvest that have accompanied the accelerated general human involvement in Prince William Sound may be cause for additional concern since populations of black bears in this particular area may be vulnerable to exploitation for ecological and behavioral reasons. In this area, habitable terrain is limited in depth (remoteness) by extensive snowfields and glaciers and is finely divided into small units by them and by numerous narrow fiords and bays. Because of the configuration of this habitat and the excellent accessibility afforded hunters by waterways, the farthest a bear can be from a point of access is about 10 km; in most instances, this distance is less than 2 km.

When one considers the propensity of bears to make extensive annual movements, home range sizes of 80 and 25 km^2 for males and females, respectively, are not unreasonable (Amstrup and Beecham 1976) and to move to and concentrate in relatively open areas where food is locally abundant, even individuals that normally inhabit the most remote portions of available habitat are probably vulnerable at sometime during the hunting season. Black bears in the Prince William Sound area appear to conform to these behavioral patterns (McIlroy 1972). In fall, bears move to subalpine areas to feed on berries, in early spring they move to snowfree beach fringe habitats and avalanche slopes to feed on newly growing vegetation, and in late summer they move to tidewater streams to feed on spawning salmon. In each case, these food sources attract bears from areas relatively inaccessible to hunters to those areas where access and visibility make the bears highly vulnerable to hunting.

Under this combination of circumstances, essentially each bear in the entire area may be vulnerable to hunting at sometime during the year. The existence of inaccessible and spatially protected segments of the population, which might theoretically function as nuclei for repopulation, appears to be a physical impossibility. Burton (1975) presented circumstantial evidence indicating that in an essentially unhunted area adjacent to one heavily hunted, recruitment to the hunted population was mostly attributable to immigration rather than to reproduction by the resident population of bears. Similarly, Beecham (1980) believed that such unhunted "reservoirs" and migration corridors were important factors in maintaining the integrity of hunted populations of bears in Idaho. Though obviously not vital to the survival of hunted bear populations, the existence of "emigration reservoirs" can mask actual resilience of bear populations. Harvest rates that appear conservative for 1 population may in reality be excessive for another apparently similar population.

In this physical environment of northwestern Prince William Sound, not only may individual bears be vulnerable, but entire local populations may also be relatively vulnerable to hunting. Since glaciers, extensive snowfields, and large bodies of salt-water divide the northwestern portion of Prince William Sound into many "discrete and complete" ecological units, there may be numerous relatively, noninteracting subpopulations of bears in this particular geographical area. It is conceivable that under intense hunting pressure and harvest, the physical environment could actually affect the reproductive resilience of a local sub-population.

The relatively prominent role of black bears in the northern and western Prince William Sound ecosystem is somewhat unique. Except for a handful of goats (Oreamnos americanus) and even fewer deer (Odocoileus hemionus sitkensis), this area is devoid of ungulates. Aside from substantial densities of black bears (perhaps approaching 0.5 bears/km^2), terrestrial carnivores are limited to a few land otters (Lutra canadensis), minks (Mustela vison), and wolverines (Gulo gulo); foxes (Vulpes vulpes), coyotes (Canis latrans), and lynx (Lynx canadensis) are uncommon; and brown bears (Ursus arctos) are absent. Black bears are the dominant terrestrial mammal in the northern and western Prince William Sound ecosystem. It is apparent that the ultimate impact of the activities of man on black bears and their habitat in Prince William Sound deserves special attention.

Because of the anticipated increase in recreational use of the black bear resource, the "limited" and highly accessible nature of the habitat, the behavior responsible for extensive movements and seasonal concentrations in open and readily accessible habitat, the likelihood for distinct subpopulations of bears, and the relative uniqueness of this ecosystem, there is an immediate need for intensive biological research and perhaps a more restrictive management program for black bears in Prince William Sound.

For these reasons, and because of the dearth of information on black bears in Alaska, in 1974 the Department of Fish and Game initiated a research project designed to gather more detailed information on the status of populations of black bears in western Prince William Sound. Ultimate goals of this study were to provide general information on the basic life history of black bears in Prince William Sound and specific information on movements; habitat use; and size, productivity, composition, and identity of populations of black bears inhabiting the northwestern portion of Prince William Sound. Additionally, this research would provide biological information applicable to management of other coastal populations of black bears.

The 1st phase of research necessitated selection of an appropriate study area and development of techniques for capturing and handling bears in this coastal Alaskan habitat. Phase 1 was completed and reported (Modafferi 1978a). Subsequent interim progress reports summarized field studies conducted through June 1978 (Modafferi 1978b), through June 1979 (Modafferi 1979), and through June 1980 (Modafferi 1980) and dealt primarily with alterations and refinements in capturing and handling techniques, applications of radio telemetry to the study of black bears in coastal habitats, and ecological implications of findings from capture and telemetry aspects of the study.

The purpose of this final report is to review research results obtained through June 1981, some of which have been previously published as progress reports, and to present a comprehensive overview, discussion, and summary of salient findings of the entire study and to point out their relevance to management of this species.

OBJECTIVES

To delineate populations; to determine home ranges and movement patterns; to determine population densities, sex and age composition, vulnerability to hunting, and mortality by sex and age class; to determine habitat use and preference; and to gather basic life history information on black bears in Prince William Sound.

PROCEDURES

The most suitable method for obtaining the types of data necessary to satisfy the aforementioned research objectives was through a radio telemetry-based study. However, before telemetric methodology could be implemented, tested, and developed, techniques for capturing and handling black bears in a coastal marine habitat had to be developed. It was important that these techniques enabled the capture of an adequate (numbers and representativeness) sample of bears in the geographical area selected for study.

It has long been common knowledge that black bears in the Prince William Sound area gather at coastal streams in late summer to feed on spawning salmon. It was believed that with the appropriate capture technique an adequate sample of black bears could be obtained at those streams. Since the Aldrich foot snare had been used to capture black bears in a number of studies (Miller et al. 1970, Jonkel and Cowan 1971, and Poelker and Hartwell 1973) and had been successfully used to capture brown bears along streams in Southeastern Alaska (Wood 1973), it appeared to be an ideal technique to capture a sample of black bears in Prince William Sound.

In 1974, all streams and streamside areas in northwestern Prince William Sound were surveyed for the presence of spawning salmon and bear sign, respectively, to assess their potential use as trapping sites and to determine their spatial distribution throughout this geographical area (Charles Irvine, pers. commun.).

The initial attempt to field test the utility of foot snaring as a capture technique in 1975 was precluded due to a scarcity of spawning salmon in the streams and a lack of bear sign along those same streams. In spite of the lack of salmon, I was puzzled why bears were not at least "waiting" in the streamside areas, anticipating a later than usual run of fish (if salmon were a vital annual dietary constituent).

Reconnaissance of these same streams in summer 1976 revealed substantial numbers of spawning salmon and a significant amount of bear sign. Trapping activities commenced in August; 15 different bears were captured while trapping at 5 different streams: Harrison Creek, Pirate Creek, Tebenkof Creek, Blackstone Creek, and Paulson Creek. Results of these initial capturing efforts were considered successful and reliable enough as a basis for telemetry type study. It was further believed that by applying experience gained during these initial trapping efforts, by increasing the number of snares in each area, and by trapping an additional stream, an even greater degree of success in capturing bears could be achieved in subsequent years. A detailed account on initial development of capture techniques and handling procedures has been published (Modafferi 1978a).

From experience gained during field activities in 1976, the Tebenkof Peninsula was selected as the area to test radio telemetry techniques and to intensively study movements and population characteristics of black bears.

In 1976, 12 different bears were captured in foot snares set in trails at 3 streamside areas: Tebenkof Creek, Blackstone Creek, and Paulson Creek. These streams were all on the north and east sides of the Tebenkof Peninsula. Although there were several streams on the west side of this peninsula, very few salmon spawned in them; consequently, they did not attract bears. By utilizing such a capture technique, bears occupying about one third of the study area may not be sampled. Therefore, in an attempt to capture bears along the eastern shoreline of Tebenkof Peninsula in July 1977 before bears normally were attracted to or arrived at streams to feed on spawning salmon, foot snares were placed in 11 baited cubby sets, distributed along the eastern coastline from Willard Creek to Blackstone Point. Techniques for setting foot snares at cubbies were similar to those employed by Flowers (1977).

In August 1977, trapping with foot snares set along streams containing spawning salmon was resumed at 4 locations: Tebenkof Creek, Blackstone Creek, Halferty Creek, and Paulson Creek. Halferty Creek had been visited, but not trapped in 1976. Captured bears were handled as in 1976 and were collared with either of 2 different types of radio-transmitting collars: an expandable type or a fixed size type. Radio-transmitting collars were manufactured by AVM Instruments, Champaign, Ill. To capture additional bears, to install new collars on bears previously collared, and to assess both the condition of bears previously collared and the collars that had been worn for a year, in August 1978, foot snares were set along the same salmon streams trapped in 1977. Only 1 bear was captured during the 1978 field season. Handling and collaring procedures were essentially the same as employed in 1977.

Because of the poor success experienced with the foot snaring technique in 1978, a different capture technique was tested in 1979. In 1978, field observations at the time of trapping indicated that few bears were visiting streams to feed on spawning salmon. The inconsistent presence of bear sign indicated that these bears were only infrequently feeding on salmon. Because so few bears were feeding on salmon and their activities were not concentrated or intense enough to be predictable, the trail set foot snaring technique proved to be an ineffective capture method.

Since it was still believed that streams containing spawning salmon were the ideal location to capture a sample of bears, another type of trap (baited, barrel-type live trap) and technique were tested. Because bears could be attracted to this type of trap and the presence of established bear trails was not imperative, I envisioned this technique to be more productive than foot snaring in any year and much more efficient in years when few bears visited salmon spawning areas.

In August 1979, baited, barrel-type live traps were placed along the same 4 streamside areas trapped in previous years. Barrel-type traps were developed and used in Minnesota (Rogers 1977) and also successfully used by Schwartz and Franzmann (1980) on the Kenai Peninsula, Alaska. This capture technique proved to be relatively unsuccessful, and its applicability and reliability in a coastal area presently remains questionable. However, the technique was judged to be more efficient than foot snaring would have been under similar field conditions. Handling and collaring techniques employed were similar to those of the previous year. It was apparent that this and all other capture techniques tested were not sufficiently efficient and consistently dependable to obtain a sizable and representative sample of bears.

A new type of radio-transmitting collar was ordered (Telonics, Mesa, Ariz.) for use in summer 1979, but the order was backlogged until after completion of field activities that year and the new equipment could not be tested. These new transmitting collars had several novel features: 1) an inverse activity mode which may furnish information on activity and increase battery life by decreasing pulse rates following a predesignated period of non-activity and 2) a prepunched, durable, flexible, nonabrasive collar material.

In addition to the relatively poor and inconsistent success in trapping bears at salmon streams, very few old adult males had been captured. Since a relatively high percentage of the bears observed in coastal grass/sedge flat habitats in early spring and killed by hunters are old males, it was believed that this segment of the bear population may likewise be vulnerable to capture in early spring with baited barrel-type traps placed in grass/sedge flat habitats.

Several weeks before I was to test the utility of capturing bears, (particularly adult males) with baited barrel-type traps placed in grass/sedge flat habitats in spring, I learned of another potential capture technique. Contrary to previous expectations, and incidental to the capture and collaring of brown bears in another study in spring 1980, it was found that black bears, even in timbered areas, could be effectively and efficiently darted with an immobilizing drug and herded and captured with the aid of a helicopter and fixed-wing aircraft. This capture technique and immobilization with an Etorphine/Rompun mixture were similar to that used for the capture of brown bears in Interior Alaska (Spraker et al. 1981).

In spring 1980, both capture techniques, aerial and baited barrel-type traps, were simultaneously tested for their usefulness in capturing black bears in a coastal habitat.

Captured bears were collared with either AVM expandable or Telonics fixed-size radio-transmitting collars. Data collected from captured bears were similar to those gathered in previous years.

While removing barrel-type traps from the study area in August 1980, several were baited and set for 1 day at locations where an abundance of bear sign was seen and where bears had been observed during routine radio-relocation flights. Information on the apparent use of salmon by bears was also noted while visiting the various streams.

Radio-collared bears were relocated with a hand-held antenna from a skiff and from antennae mounted on wing struts or wings of a fixed-wing aircraft (PA-18 and Cessna 172). Radio-relocating flights were attempted a minimum of once a week, weather permitting. Locations of bears were plotted on U.S. Geological Survey topographic maps (scale 1:63,360).

In spring and summer 1979, samples of items known to be eaten by bears were collected for chemical analyses.

STUDY AREA

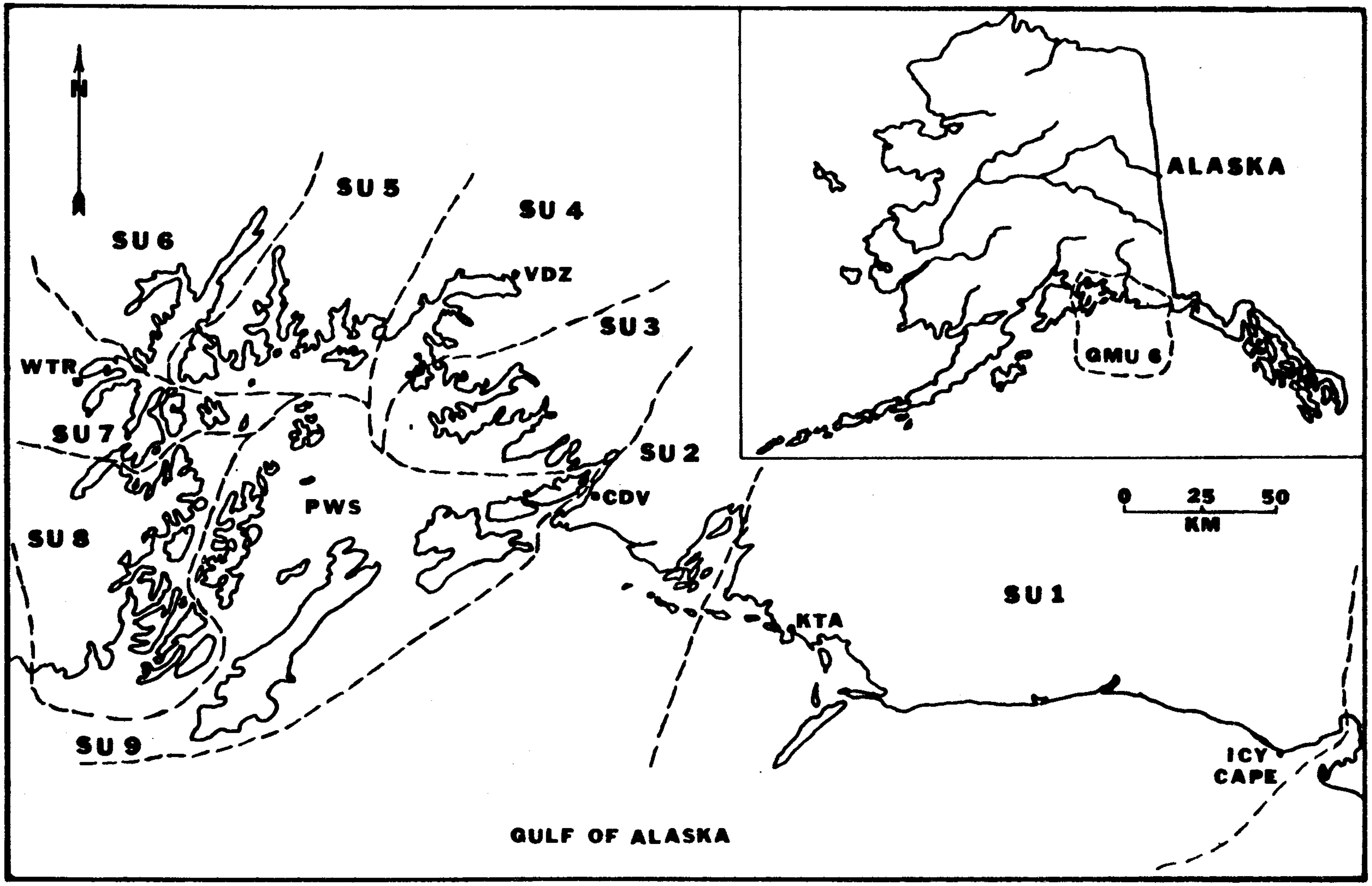
Field research for this study took place in Southcentral Alaska along a portion of coastal habitat in northwestern Prince William Sound. The field research area is located within the northwestern portion of Game Management Unit (GMU) 6 and within Chugach National Forest, administered by the Alaska Department of Fish and Game and U.S. Forest Service, respectively. Supplementary information was collected from bears killed by hunters on islands and areas located on the periphery of Prince William Sound. These data were tabulated by geographical management subunits within GMU 6 (Fig. 1). (The geographical management subunits were identified for research purposes only and are not to be confused with offically designated subunits with GMU 6.)

Prince William Sound is isolated from the Gulf of Alaska by 3 large islands and encompasses about 60,000 km^2 of surface water. Its coastline to the north and west is extremely irregular due to numerous complex fiords which penetrate the mainland. In many locations, continuity of the coast is interrupted by streams, tidal marshes, and glaciers, and the latter extend to tidewater in many locations.

The entire Prince William Sound Basin was covered by a mass of ice at the culmination of the Wisconsin glaciation. It is believed that a noncontinuous withdrawal of ice from the sea began in post-Wisconsin time. Presently, more than 30% of the uplands in the northwestern portion of the Basin are still shrouded in glaciers. Glaciers to the north originate from snowfields of the Chugach Mountain Range where elevations reach 6 km (only 15 km from the tideline) and those to the west flow from snowfields of the Kenai Mountain Range where elevations of 2 km commonly occur less than 5 km from saltwater. Arms, trunks, and cascades of glaciers, some of which extend into the deep fiords, radiate from the broad neve and appear to compartmentalize terrestrial habitat. These extensive icefields also profoundly influence local ecological conditions through effects on weather.

Climatic records for the northwestern Prince William Sound region are scanty, but the general area is definitely under oceanic influence. However, maritime climatic conditions that prevail along the open coasts, are not typical of the ice-surrounded

Fig. 1. Location of black bear study area in Alaska. Field research was conducted in management subunits (SU) 6 and 7. Data on hunter killed bears originated in SU 4 - 8. (WTR = Whittier, VDZ = Valdez, CDV = Cordova, KTA = Katella, PWS = Prince William Sound and GMU = Game Management Unit.)



fiords where extremes are greater and general weather is more continental in nature. Mean monthly temperatures for the area range from about 13°C in July/August to about -6°C in January/February. Precipitation varies tremendously locally and probably ranges from 150 to 370 cm per year with the proportion of snow increasing from the southeast to the northwest where over 260 cm of snowfall near sea level is not unusual.

Topography of land surrounding northwestern Prince William Sound is characterized by coastal slopes rising precipitously to elevations of 6 km on the projecting peninsulas and to elevations of 12-20 km on the mainland proper at the heads of fiords. This general land form is greatly complicated by an intricate network of small steep haphazardly arranged watersheds. Valley bottoms are occupied by streams originating from glacial, spring, or runoff sources. Most streams in the area are short, 100 m to 7 km in length, and though tributaries are mostly lacking, some commonly braid while passing through grass/sedge flat habitat (1-50 ha in size) prior to reaching saltwater.

Vegetative communities on the north and western coast of Prince William Sound characteristically occur in horizontal bands distributed altitudinally between tideline and permanent ice fields or rocky mountain peaks. Continuity of these strata is frequently interrupted by bog meadows and vertically oriented effects of cascading glaciers and snow- or rock-avalanche tracks.

The 6 prominent vegetative associations include: 1) grass/ sedge tidal flat, 2) coniferous forest, 3) bog meadow, 4) avalanche track, 5) subalpine tundra, and 6) alpine tundra.

Beach rye grass (Elymus arenarius), silverweed (Potentilla sp.), and sedges (Carex spp.) are common along tideline where a sand substrate is present and may cover large expanses on tidal flat stream alluvia.

Stands of Sitka spruce (Picea sitchensis), Western hemlock (Tsuga heterophylla), and mountain hemlock (T. mertensiana) cover most coastal slopes; the latter species usually predominates and in some locations extends from near tidewater to timberline (300-600 km). Forests are greatly reduced in heavily glaciated fiords. Blueberry (Vaccinium spp.), Menziesia ferruginea, bramble (Rubus pedatus), and goldthread (Coptis trifolia) commonly occur in the forest understory.

Moist semi-shaded lowland sites are characteristically vegetated with several species of Polypodiaceae (Cystopteris sp., Blechnum sp. and Dryopteris sp.), yellow skunk cabbage (Lysichiton americanum), twisted-stalk (Streptopus amplexifolius), false hellebore (Veratrum viride), beach lovage (Ligusticum sp.), and Angelica sp.

Bands of vegetation, including alder (Alnus crispa), salmonberry (Rubus spectabilis), devil's club (Echinopanax horridum), lady fern (_Athyrium filix-femina_), horsetail (_Equisetum_ spp.), Graminae (_Arctagrostis latifolia_ and _Calamagrostis_ sp.), cow parsnip (_Heracleum lanatum_), and false hellebore frequently occur in subalpine habitats above coniferous forests and in snow-avalanche tracks.

Fauria crista-galli, _Sphagnum_ spp., _Empetrum nigrum_, and _Carex_ spp. lushly carpet wet meadow/bog habitats which occur in the poorly drained depressions characteristic of the terraced coastal slopes.

Vegetation on the mountain peaks and ridges is dominated by species as: crowberry, _Lycopodium_ sp., _Carex_ spp., and lichens.

More extensive descriptions of vegetation that occurs in the area can be found in Cooper (1942) and McIlroy (1970).

Since there is not a road system within the area, human access is primarily by float-equipped aircraft and boat. Ports of Valdez and Whittier (and to a lesser extent, Seward) are major points of departure for boats. Whittier is about a 30-min aircraft flight from Anchorage.

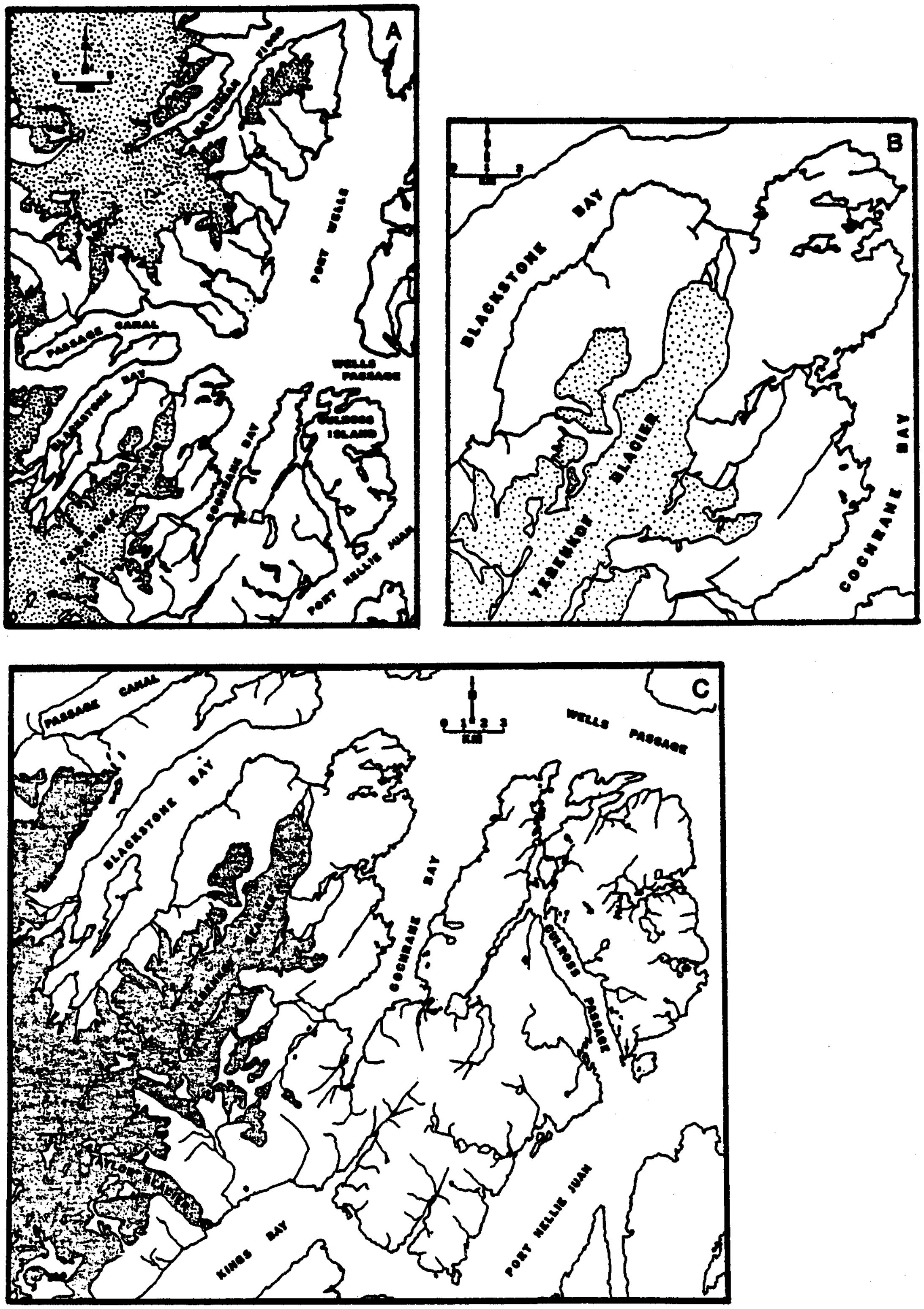
About 90% of the black bears killed in GMU 6 are taken by boat-transported hunters during the spring season. Inclement weather, which is not uncommon in the area in early spring, greatly affects the activities of hunters; however, in its absence, hunter success is relatively high. During the spring season, male bears usually far outnumber females in the kill.

For various reasons, the geographical boundaries of the field research area were varied to accommodate particular phases of this study.

Because field activities in 1976 were primarily designed to provide familiarity with the general area and with logistics of working in that area, as well as to perfect techniques for capturing and handling black bears in typical coastal habitat, streams where trapping took place were selected primarily by the amount of fish and bear sign in each area (Fig. 2A). Spatial relationships and distribution of the streams were of secondary consideration.

In 1977, a smaller portion of this area was selected for testing and development of a telemetry system and for intensive study of movements and population characteristics of bears. The area elected (the Tebenkof Peninsula) had good numbers of bears, was readily accessible to hunters, had numerous salmon spawning streams where bears could be captured, was a somewhat discrete geographical unit because of glaciers and fiords, was convenient for conducting field activities because of its proximity to Whittier, and was convenient for routine aerial radio tracking because of its proximity to Anchorage. Field research activities

Fig. 2. Location of areas used during different phases of field research on black bears in northwestern Prince William Sound, Alaska, 1976–80. (A = area selected for perfecting capturing and handling techniques. B = area selected for developing telemetry techniques and studying movements. C = area selected for testing aerial capture techniques and studying movements.)



in 1978 and 1979 were also centered in this same 75 km^2 area (Fig. 2B).

In spring 1980, due to the increase in mobility provided by the use of aircraft in capturing bears and because several previously radio-collared bears had ranged outside this geographical unit, the area in which bears were pursued, captured, and radio-collared was enlarged to include Culross Island and the peninsula of land to the east and south of Cochrane Bay (approximately 400 km^2) (Fig. 2C). During the same period, barrel-type live traps were placed in grass/sedge flats located in a smaller portion of the general area where bears were pursued with aircraft.

RESULTS

Live Capture Sample

Between 28 July and 28 August 1976, 15 different black bears were captured, measured, marked, bled, and released, while trapping with foot snares placed along streams containing spawning salmon (Fig. 3 and Appendix A). Streamside areas where trapping occurred included Harrison Lagoon, Pirate Cove, Tebenkof Creek, Blackstone Creek, and Paulson Creek. One bear, a female repeat recapture, was fitted with a radio-transmitting collar.

Between 18 and 29 July 1977, no bears were captured. During this same period, no bear signs were observed near 11 locations where foot snares were placed in baited cubbies spatially removed from streamside areas trapped in 1976 (Fig. 4).

In 1977, though snares were set in a smaller geographical area and at fewer locations than in 1976, between 6 and 28 August, 14 different bears were captured, measured, marked, bled, collared with radio-transmitters, and released while trapping with foot snares placed along streams containing spawning salmon (Fig. 3 and Appendix A). Five of the bears captured were recaptures from 1976, 2 were captured at the same location, and 3 were captured at a location not trapped in 1976. Streamside areas where trapping occurred included Tebenkof Creek, Blackstone Creek, Halferty Creek, and Paulson Creek.

From 10 to 28 August 1978, in spite of greater effort in trapping with foot snares than in previous years, only 1 black bear was captured, measured, marked, fitted with a radio-transmitting collar, and released (Appendix A).

From 31 July to 26 August 1979, 6 individual black bears were responsible for 13 captures in baited barrel-type live traps placed along the same 4 streams where trapping occurred in 1978 (Appendix A). One female was captured on 4 occasions, 3 times at 1 location. One female and 2 of her cubs accounted for 7 total captures. This female and 1 of her cubs were each captured 3

Fig. 3. Location of streams where spawning salmon occur (stars) and streams where trapping took place during development of capturing and handling techniques in northwestern Prince William Sound. (HL = Harrison Lagoon, PC = Pirate Cove, TB = Tebenkof Creek, BC = Blackstone Creek, HF = Halferty Creek, PL = Paulson Creek and WK = Wicket Creek.)

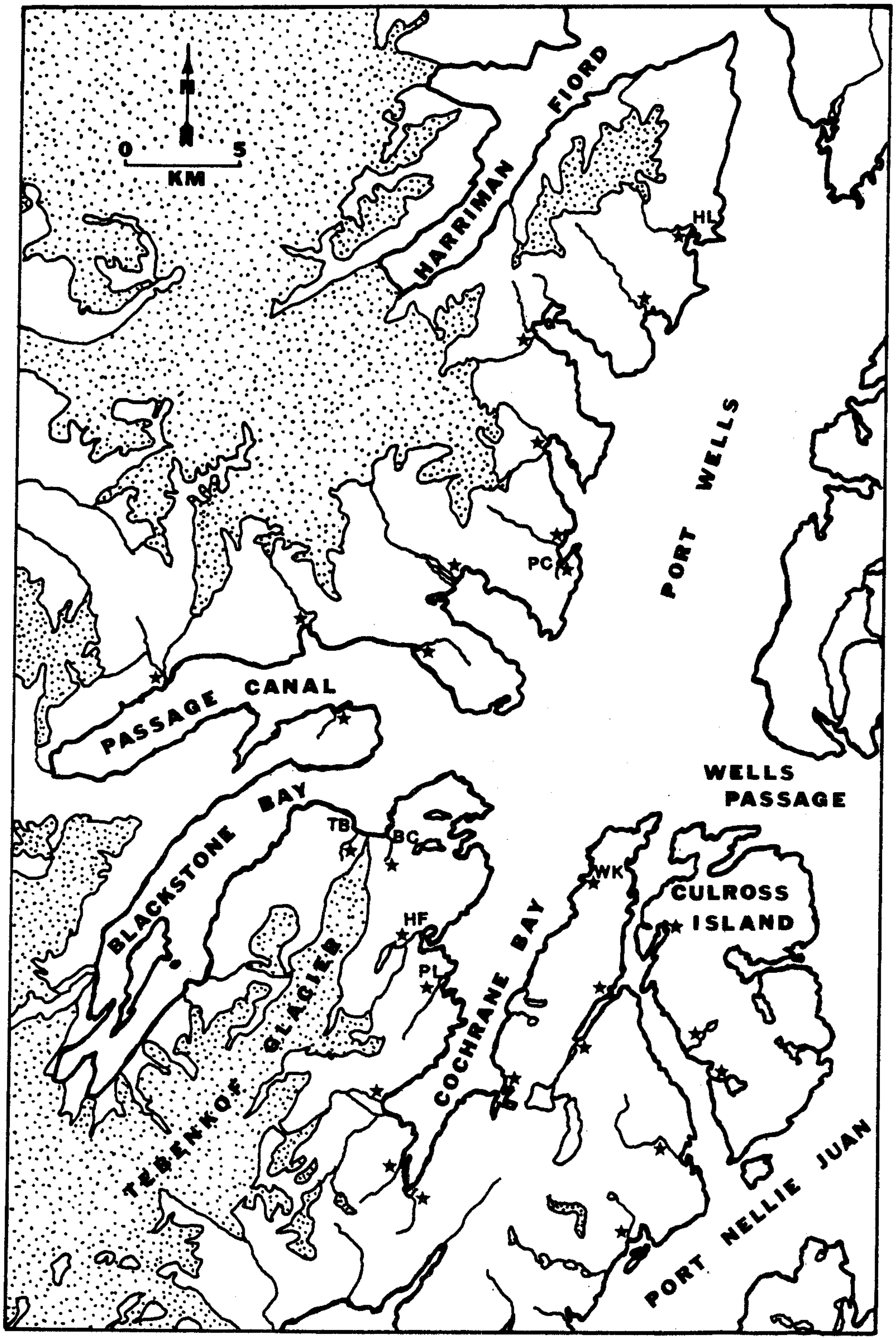
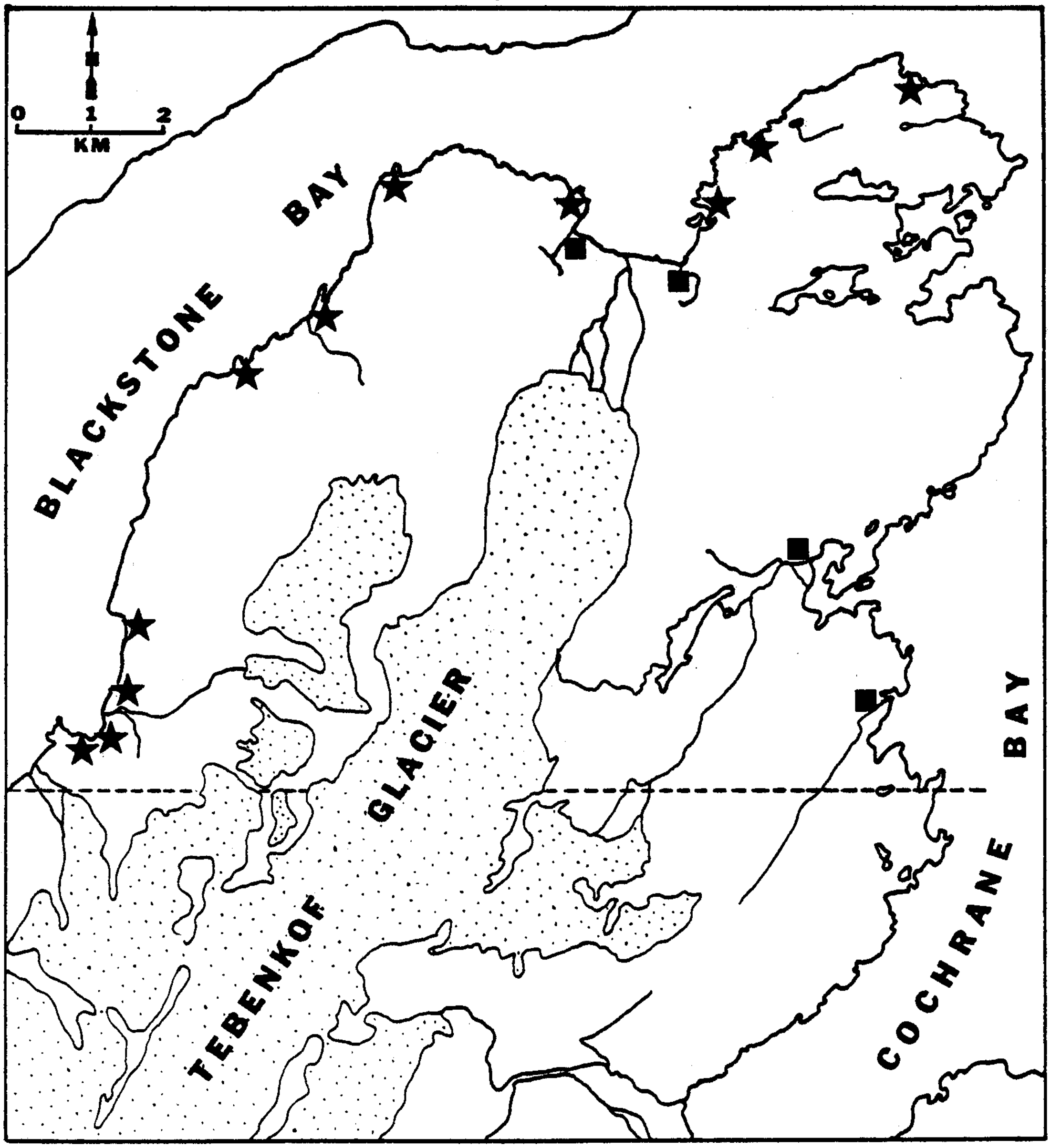


Fig. 4. Spatial relationship of locations where foot snares were placed in baited cubbies (stars) to streamside locations where foot snares were placed along streams containing spawning salmon (squares) in northwestern Prince William Sound, Alaska.



times at the same location. Captured bears were measured, marked, collared with radio transmitters, and released. One female bear was found dead in a barrel-type trap; at the time of her death, her fur was wet and matted.

Between 15 and 25 May 1980, 1 adult male black bear was captured, measured, marked, collared with a radio transmitter, and released while employing baited barrel-type live traps located on the periphery of sedge/grass meadows near high tidewater (Fig. 5 and Appendix A). In numerous instances, the traps were found untripped with the bait removed or tripped without the bait removed.

From 20 to 23 May 1980, with the aid of a fixed-wing aircraft (flight time, 23 hours) and a helicopter (flight time, 16 hours), 13 different black bears were sighted, tranquilized, captured, measured, marked, collared with a radio transmitter, and released (Fig. 5 and Appendix A). Five of the bears captured were recaptured from previous years, 3 males from 1976, 1 female from 1976, and 1 female from 1977.

On 23 July and 6 August 1980, incidental to other field activities, 1 male and 1 female black bear, respectively, were captured at Tebenkof Creek and Wicket Creek in baited barrel-type live traps placed near streams containing spawning salmon, measured, marked, collared with radio transmitters, and released (Fig. 5 and Appendix A).

Efficiency of capturing black bears with foot snares or baited barrel-type traps in summer along streams containing spawning salmon was variable between years and areas (Table 1). In 1976, 16 bears were captured in 437 trap nights; but in 1978, only 1 bear was captured in 1,023 trap nights.

In 1976, 12 bears were captured after 288 trap nights of effort at Tebenkof and Blackstone Creeks; the 2 streams were only 1.5 km apart. Yet, in 1977 and 1978, 4 and 0 bears were captured after expending 625 and 598 trap nights of effort, respectively, at the same 2 streams.

In 1977, 9 bears were captured at Halferty Creek with 249 trap nights of effort; in 1978, 351 trap nights of effort in the same area produced only 1 bear.

Similarly, data collected in 1979, while trapping with barrel-type traps, indicated that few different bears were visiting either Tebenkof, Blackstone, or Halferty Creeks. Though 8 captures were made, only 3 different adult individuals were involved.

Paulson Creek had early, relatively large and consistent annual runs of salmon, but no more than 1 bear was captured there in any year.

Fig. 5. Locations where trapping with baited barrel-type live traps occurred (letters) and locations where bears were captured with a helicopter (numerals bear ID. number) in northwestern Prince William Sound, Alaska, May 1980. (WL = Willard Creek, TB = Tebenkof Creek, BC = Blackstone Creek, SC = Surprise Cove, HF = Halferty Creek, PL = Paulson Creek and WK = Wicket Creek.) Darkened areas = glaciers.

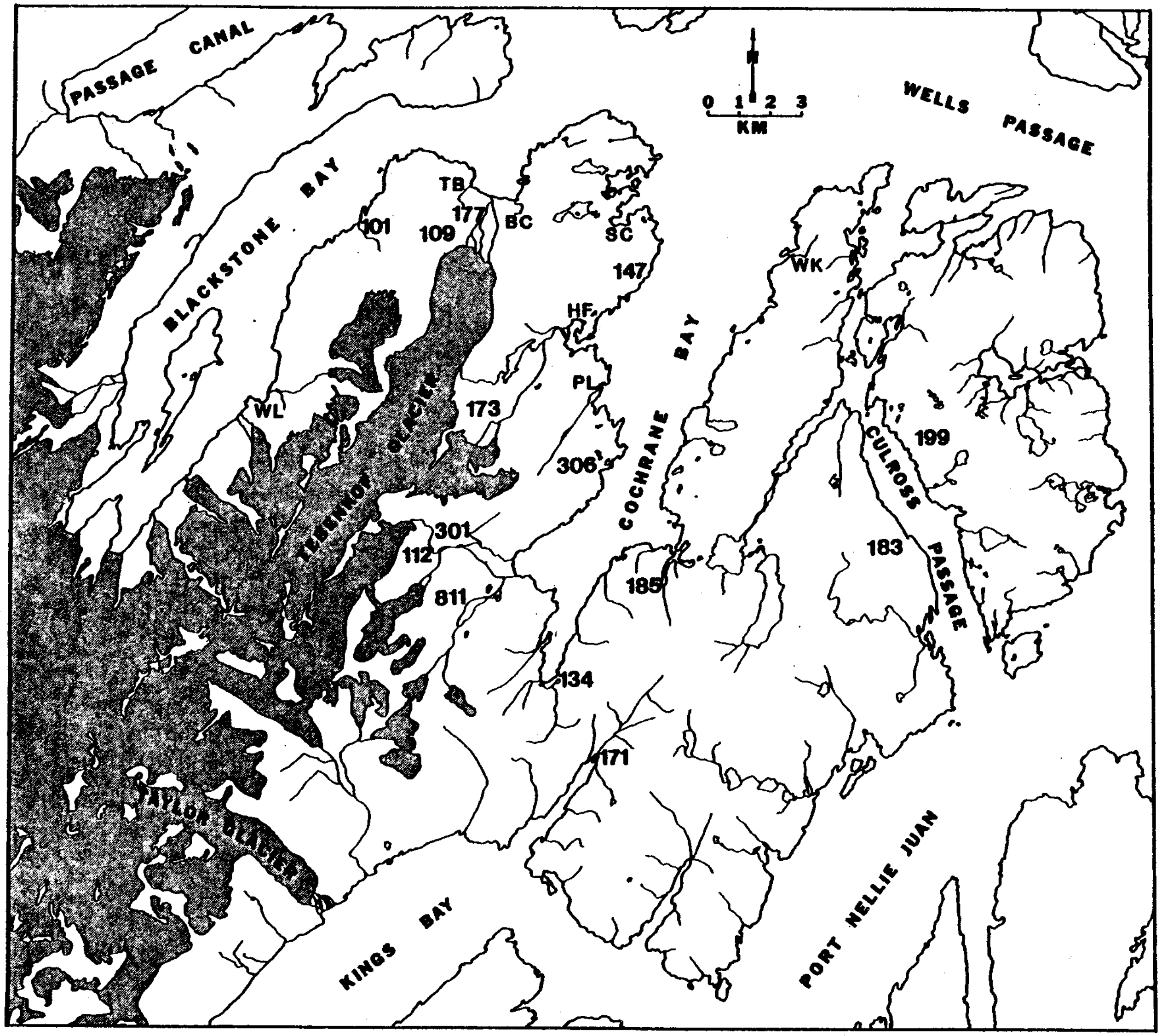


Table 1. Efficiency of capturing black bears with foot snares or barrel traps along streams containing spawning salmon in western Prince William Sound, 1976-80.

	Foot Snares						Barrel Traps			
	1976		1977		1978		1979		1980	
Location	Tn[1]	Cap[2]	Tn	Cap	Tn	Cap	Tn	Cap	Tn	Cap
Harrison Lagoon	53	2	-[3]	-	-	-	-	-	-	-
Pirate Cove	47	1	-	-	-	-	-	-	-	-
Tebenkof Creek	217	8	464	2	411	0	150	2	2	1
Blackstone Creek	71	4	161	2	187	0	40	6	-	-
Halferty Creek	-	-	249	9	351	1	150	4	-	-
Wicket Creek	-	-	-	-	-	-	-	-	1	1
Annual Totals	337	16	932	14	1023	1	709	13[4]	3	2
TN/CAP	21		67		1023		27		1.5	

[1] Tn = trap nights

[2] Cap = captures

[3] - = area not trapped

[4] Includes 2 instances of 2 bears captured in the same trap at the same time

In 1980, 2 bears were captured in baited barrel-type traps, incidental to other activities and with a minimum of trapping effort compared to any previous year.

Data gathered from bears captured with foot snares or barrel-type traps during summer along streams containing spawning salmon indicate an overall sex ratio of 24 females:14 males (63% females) and that the sex ratios for most area x year categories were also skewed toward females and the average age for 12 noncub males was 3.3 years (Table 2 and Appendix A). Similarly, the sample of 13 bears captured in spring with a helicopter contained 69% females (9 females and 4 males), but the average age for 4 noncub males was 7.8 years (Appendix A).

During spring 1980, 114 trap nights' effort led to the capture of 1 bear and the incidental capture of a wolverine (Table 3). Traps were frequently found without bait and untripped (10) or tripped but with the bait still present (7). Tripped traps and missing bait were attributed to other carnivores and birds.

The timing and capture of bears did not appear to correlate directly with the arrival of salmon runs and availability of fish in the streams. Dog salmon (Oncorhychus keta) were found in many streams in mid-July and early runs of pink salmon (Onchorhynchus gorbuscha) started to arrive at most streams by this same time. By the end of July, good numbers of early run pinks were found in most streams; by 10 August, early runs were spawning and late runs had arrived in the streams.

Considering the 4 years (1976-79) when trapping occurred along streams where spawning salmon were present, only 20% of the bears were captured before 9 August and more than 55% of the captures were made after 14 August (Table 4).

These data indicate that few bears were in streamside areas when salmon first arrived and that most bears probably arrived at the streams a week or so after numerous fish became available.

Data on repeat captures (individuals captured more than once in the same year) and recaptures (individuals captured in more than 1 year) indicate that individual bears may remain in the same streamside area as long as spawning salmon are available or they may make excursions up to 6 km in traveling from 1 stream to another (Table 5). These data further indicate that some individuals may utilize the same streamside areas in consecutive years or in different years they may travel up to 6 km to other streamside areas where spawning salmon are also available (Table 5).

One individual female (No. 106) was captured at either Blackstone or Tebenkof Creeks in 3 of the 4 years trapping occurred. Such data indicate that at least some bears were not immune to being recaptured and indicate that these techniques may provide information that requires repeat and/or recapture data.

Table 2. Sex, location, and annual differences for numbers of black bears captured with foot snares or barrel traps along 7 different streams containing spawning salmon in northwestern Prince William Sound, Alaska, 1976-80.

	Foot snares						Barrel traps					
	1976[1]		1977		1978		1979		1980		Total	
Location	F	M	F	M	F	M	F	M	F	M	F	M
Tebenkof Creek	5	2	2	1	0	0	1	0	0	1	8	4
Blackstone Creek	3	1	1	0	0	0	2	1	-[2]	-	6	2
Harrison Creek	1	1	-	-	-	-	-	-	-	-	1	1
Pirate Cove	0	1	-	-	-	-	-	-	-	-	0	1
Paulson Creek	0	1	1	0	0	0	0	1	-	-	1	2
Halferty Creek	-	-	5	4	1	0	1	0	-	-	7	4
Wicket Creek	-	-	-	-	-	-	-	-	1	0	1	0
Total	9	6	9	5	1	0	4	2	1	1	24	14

1 F = female and M = male.

2 Hyphen (-) = Not trapped.

Table 3. Efficiency of capturing black bears with baited barrel-type live traps in spring (15-26 May) in northwestern Prince William Sound, Alaska, 1980.

Location	No. trap nights	No. without bait	No. tripped	No. captures
Willard Creek	11	0	1	0
Blackstone Creek	20	3	2	0
Tebenkof Creek	26	3	1	1
Surprise Cove	11	0	0	0
Halferty Creek	25	2	2	0[1]
Paulson Creek	10	1	0	0
Wicket Creek	11	1	1	0
Totals	114	10	7	1

[1] One wolverine captured.

Table 4. Chronology for captures of black bears at salmon spawning areas in western Prince William Sound, Alaska 1976-79.

Date	Year				Chrono-logical totals	% total to be captured
	1976	1977	1978	1979		
Jul 24-25	-[1]	1			1	98
26-27	-	0			0	98
28-29	1	0			1	96
30-31	1	0		0	1	94
Aug 1-2	1	0		2	3	85
3-4	1	0		1	2	82
5-6	0	0		0	0	82
7-8	0	1		0	1	80
9-10	4	0	0	0	4	70
11-12	-	0	0	2	2	66
13-14	-	3	0	0	3	59
15-16	-	3	1	3	7	43
17-18	0	1	0	2	3	36
19-20	3	2	0	0	5	25
21-22	2	0	0	1	3	18
23-24	1	1	0	0	2	14
25-25	0	0	0	2	2	9
27-28	2	2	0	-	4	0
Annual total	16	14	1	13	44	

[1] Hyphen (-) = Not trapped.

Table 5. Location of repeats and recaptures for black bears captured along streams containing spawning salmon in western Prince William Sound, Alaska, 1976-79.

No.	Sex[1]	Age[2]	Year of capture 1976	1977	1978	1979
B101	F	4	TB-TB[3]	TB	-[4]	-
B106	F	14	BC	TB	-	BC-BC-TB
B107	M	2	PL	HF	-	-
B119	M	2	BC	HF	-	-
B125	F	5	BC	HF	-	-
B159	F	5	-	-	-	TB-HF-HF-HB
B146	F	c	-	-	-	BC-BC-BC

[1] M = male, F = female.

[2] Number of cemental annuli at initial capture; c = cub, less than 1 year of age.

[3] TB = Tebenkof Creek, BC = Blackstone Creek; PL = Paulson Creek, HF = Halferty Creek.

[4] Hyphen (-) = Area not trapped.

Data gathered from bears captured in spring or summer in northwestern Prince William Sound indicate seasonal differences in sex and/or age composition between samples (Table 6).

Females dominated the samples of bears captured in summer along streams containing spawning salmon. Sixty-three percent of the bears captured with this technique were females.

The sample of noncub bears captured during spring 1980 contained 64% females which had an average age (9.1 years) similar to that of the summer sample (9.1 years). The sample of 5 males captured in the spring had an average age of 7.8 years, compared to 3.3 years for the summer sample of noncub males.

Considering both sampling periods, 45% of the 31 noncub females were 10 years of age or older; whereas only 1 of the 17 noncub males was found to be older than 10 years.

Hunter Kill Sample

Ease of access, behavior of hunters, behavior of bears, season of year, and regulations prohibiting the killing of cubs or sows accompanied by cubs act in concert to influence sex and age characteristics of a sample of bears killed by hunters.

Relatively accessible areas attract more hunters and result in an increase in the intensity of hunting effort and in the numbers of bears killed. Effects of this trend in hunting kill, mediated in part by access, are reflected in the age distribution of the sample of bears killed by hunters (Table 7). For 2 respective periods, 1974-77 and 1978-80, a higher percentage of bears >9 years (18 and 21%, respectively) were killed by hunters in less accessible and lightly hunted areas than were killed by hunters in easily accessible and heavily hunted areas (10 and 12%, respectively).

Sex composition of bears killed by hunters during 1974-80 in GMU 6 is also affected by seasonal period (Table 8). The proportion of male bears killed by hunters decreased from 75% for May to 63% for June. Eighty-six percent of the 42 bears killed during 1-10 May were males. The percentage of male bears killed decreased through the latter part of May and through most of June. During the 1st week of June, 70% of 120 bears killed were males, but during the 3rd week of June, 38% of the bears killed were males.

In addition to seasonal effects, sex composition of bears killed by hunters in GMU 6 is in part affected by regulations and the intensity of hunting and kill rates of previous years; the latter in this geographical area are directly associated with ease of access (Table 9 and Appendix B).

Table 6. Sex and age for black bears captured in spring and summer in northwestern Prince William Sound, Alaska, 1976-80.

Sex	Season of capture: Summer (N, μ)	Spring (N, μ)
Female	22,[1] 17, 16, 15, 15, 14, 13 13, 12, 12, 7, 6, 5, 5, 5, 5 4, 3, 3, 3, 3, 2, c, c. 2, c, c (24, 8.4)	19, 16, 10, 10, 8, 8 6, 3, 2 (9, 9.1)
Male	9, 6, 3, 3, 3, 3, 2, 2, 2, 2, 2, 2, c, c (14, 2.9)	13, 8, 6, 6, 6,[2] (5, 7.8)

1 Age in years for each individual; c = cub, less than 1 year of age. Individuals represent different captures and recaptures, repeats not included.

2 Individual captured in baited barrel-type trap; all other spring captures were made with a helicopter.

Table 7. Age distribution (%) for 3 categories of male black bears killed (<5, 5-9, >9 years) during spring hunting seasons (January through June) in 5 different areas (geographical management subunits 4, 5, 6, 7, 8) grouped under 2 circumstantial intensities of harvest for periods, 1974-77 and 1978-80, Prince William Sound, Alaska.[1]

Treatment (subunits)	1974-77 N	1974-77 <5	1974-77 5-9	1974-77 >9	1978-80 N	1978-80 <5	1978-80 5-9	1978-80 >9
Heavily hunted								
4	38	21	68	11	29	45	38	17
6	30	65	35	0	17	65	35	0
7	19	47	42	11	22	36	50	14
Combined								
4, 6, and 7	87	33[2]	56	10	68	47	41	12
Lightly hunted								
5	60	48	35	17	24	46	42	13
8	29	24	55	21	15	20	40	33
Combined								
5 and 8	89	40	42	18	39	35	44	21

1 These geographical management subunits were identified for research purposes only and are not to be confused with officially designated Subunits within GMU 6.

2 Percentages for combined category calculated from data within that category from averaging percentages.

Table 8. Chronology for male (M) and female (F) black bears killed by hunters during the spring season in Game Management Unit 6, Prince William Sound, Alaska, 1974-81.

	Year																		
	1974		1975		1976		1977		1978		1979		1980		1981		Totals		% M
Date	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	
May																			
1 to 10	2	0	1	1	3	0	4	0	4	1	7	2	1	0	14	2	36	6	86
11 to 17	6	3	9	2	4	2	16	8	9	3	5	4	8	1	23	5	80	28	74
18 to 24	22	8	17	4	10	5	10	5	11	4	17	2	9	5	11	4	107	37	74
25 to 31	6	1	27	7	18	10	14	11	15	4	14	8	9	2	14	2	117	45	72
Subtotal	36	12	54	14	45	17	44	24	39	12	43	16	27	8	62	13	340	116	
% M	75		79		73		65		76		73		77		83		75		
June																			
1 to 7	11	2	18	5	12	12	8	7	7	2	7	4	13	3	8	1	84	36	70
8 to 14	7	3	10	1	6	7	2	2	4	1	3	1	2	0	5	7	39	22	64
15 to 21	1	0	8	9	2	8	0	1	0	4	2	1	2	2	1	1	16	26	38
22 to 30	4	0	5	2	1	2	4	1	3	1	0	0	1	0	0	1	18	7	72
Subtotal	23	5	41	17	21	29	14	11	14	8	12	6	18	5	14	10	157	91	
% M	85		71		42		56		64		67		78		58		63		
Total	59	17	95	31	56	46	58	35	53	20	55	22	45	13	76	23	497	207	
% M	78		75		55		62		73		71		78		77		71		

Table 9. Numbers and sex composition for 3 age categories (<5, 5-9, and >9 years) of black bears killed during spring hunting seasons (January through June) in Game Management Unit 6 and grouped under 2 circumstantial intensities of harvest for periods, 1974-77 and 1978-80, Prince William Sound, Alaska.

	1974-77 (N)			1978-80 (N)		
Treatment[1]	<5	5-9	>9	<5	5-9	>9
Heavily hunted		(135)			(96)	
% bears	33	54	13	48	39	14
% males	64	67	53	74	76	62
Lightly hunted		(128)			(51)	
% bears	36	45	20	39	43	18
% males	78	65	64	70	77	89

[1] Heavily hunted = geographical management subunits 4, 6, and 7; Lightly hunted = geographical management subunits 5 and 8. (These geographical management subunits were identified for research purposes only and are not to be confused with offically designated Subunits within GMU 6.)

Generally, a greater percentage of male bears were killed by hunters in lightly hunted areas, Units 5 and 8, than in the heavily hunted areas, Units 4, 6, and 7. This trend was particularly evident for the category of bears >9 years old, where 64 and 89% of the bears killed in lightly hunted areas and 53 and 62% of the the bears killed in heavily hunted areas were males for the 1974-77 and 1978-80 periods, respectively.

Data on sex and age composition, gathered from live-captured bears and a hunter-killed sample of bears from a similar geographical area indicate the following: 1) similarities in age structure within sexes and among samples; 2) similar differences in age structure between sexes for both sampling techniques; and 3) differences in the proportions of each sex between sampling techniques. These data were used to hypothetically describe the sex and age composition of the live population of bears that existed in that area in 1976 (Table 10).

Both sampling techniques provided samples with similar age structures within sex categories and contrasting age structures between sex categories. Eleven of 29 and 5 of 9 female bears which occurred in the live-captured and hunter-killed samples, respectively, were older than 9 years. Comparable data for males indicate that 0 of 16 and 1 of 17 males which occurred in the same samples were >9 years.

Assuming that the live capture and hunter kill samples originated from the same population, my data indicate a bias in sampling of sex between the 2 techniques. Data for the live-captured sample indicate that 29 of every 45 (64%) bears in the 1976 population were females. In contrast, data from the hunter-killed sample indicate that only 9 of 26 (35%) bears in that same population were females. In combination, these data suggest that 56% of the bears in that area during 1976 were females.

Movements of Females

Data gathered from relocations of radio-collared bears indicate that ranges of females were considerably smaller than those of males and that partial or extensive overlap between ranges of different individual females was not uncommon.

Females No. 101, 106, and 125, captured at either Tebenkof and/or Blackstone Creeks in 1976 and/or 1977, appeared to commmunally use the Tebenkof Glacier forelands and paralleling streamside areas in late summer when spawning salmon were available (Fig. 6). During other seasons, each appeared to utilize separate areas: No. 101 remained around the Tebenkof Creek area, No. 106 occupied areas more near and to the south of Blackstone Creek, and No. 125 occupied an area to the northeast of Blackstone Creek.

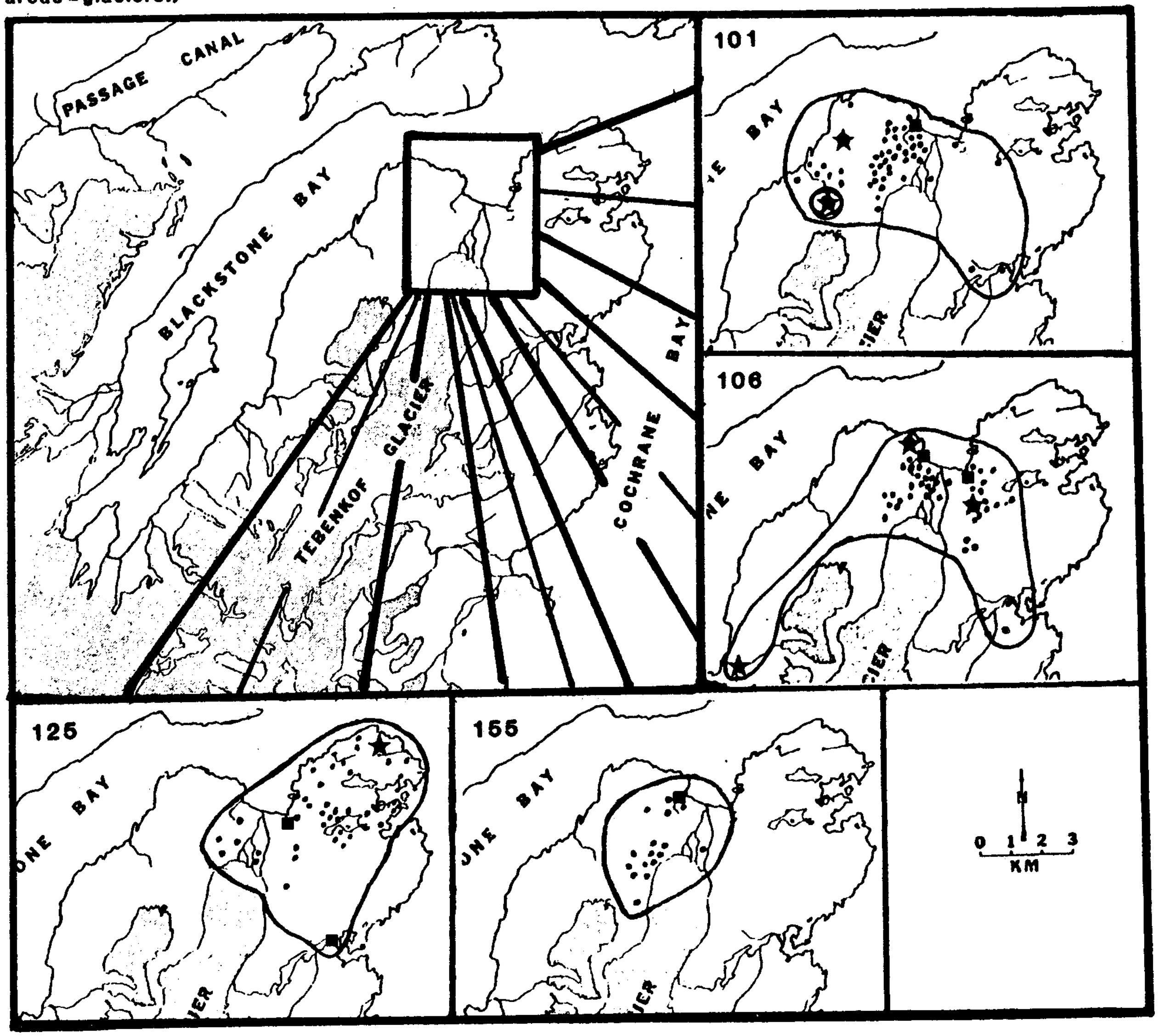
Each of these individuals made similar and rather extensive but brief movements of about 4 km out of their "normal or average"

Table 10. Hypothetical age structure and sex for the black bear population inhabiting the study area in 1976 as determined by back dating ages for individuals live captured or killed by hunters within the study area from 1976 through 1980.

Females			Males		
Captured	Killed	Combined	Captured	Killed	Combined
21[1]	16	21	9	13	13
15	14	16	9	9	9
15	13	15	4	7	9
15	13	15	4	7	9
14	12	15	2[2]	7	7[2]
14	8	14	2[2]	7	7
14	7	14	2[2]	6	7
12	4	14	2	4	7
12	1	14	2	3	6
11		13	2	3	4
10		13	2	2[2]	4
9		12	2	2[2]	4
7		12	2	2[2]	3
6		12	2	2	3
6		11	2	2	2
5		10	2	1	2
5		9		c[3]	2
4		8			2
4		7			2
4		7			2
4		6			2
3		6			2
3		5			2
3		5			2
3		4			2
2		4			2
2		4			2
2		4			2
1		4			1
		3			c
		3			
		3			
		3			
		2			
		2			
		2			
		1			
		1			

[1] age
[2] Live captured individual was subsequently killed by hunter; these individuals were only counted once in the total column.
[3] c = cub

Fig. 6. Capture sites (squares), den sites (stars), site used by sow 101 and her male cub 155 (circled star), radio-relocations (dots) and ranges for 3 radio-collared female black bears and a related yearling male (155) which exhibited communal use of a particular area in northwestern Prince William Sound, Alaska. (Darkened areas = glaciers.)



range to Halferty Creek (in summer 1978 for No. 125, in the late summer-fall period of 1978 and 1980 for No. 101, and in 1978 for No. 106). These bears then returned to more commonly used areas by late fall.

In late fall, individuals No. 101 and 106 made forays, again out of their "average" range, into the Blackstone Bay area on the eastern watershed of the Tebenkof Peninsula where they denned. Female No. 101 utilized this area for denning in 1977 and 1978; circumstantial evidence indicated the area was also used in 1980. No. 106 denned there in 1980. Radio-collared individuals were only relocated in this area during the predenning, denning, and postdenning periods.

Females No. 137, 141, and 147, captured at Halferty in summer 1977, appeared to exhibit a communal range relationship; movements of all 3 were essentially limited to the same 30 km^2 geographical areas on the northeast side of Tebenkof Peninsula (Fig. 7).

Information presented in Fig. 8 illustrates relative size and spatial arrangement of ranges for most of the radio-collared females bears, excluding several of those previously reported on (Figs. 6, 7).

Most of these data were derived from radio locations collected in summer and fall 1980. The data indicate apparent overlap in ranges of bears where a sufficient number of observations are available for individuals with contiguous ranges (i.e., east side of Tebenkof Peninsula). These data do not indicate a communal range relationship as presented for individuals in Fig. 7, but more so, exhibit communal use of a particular area (as presented for individuals in Fig. 6) and perhaps at a specific time such as late summer when streams contain spawning salmon.

Movements of Males

Since few adult male bears were captured during most phases of this study, data presented on movements of males were derived from a small sample of individuals and generally lacked continuity. However, these few data do indicate that ranges of males are larger than those of females, that ranges of males overlap spatially, and that annual movements over distances of 40 to 70 km may be typical for males (Figs. 9, 10).

In less than 1 year, a 3-year-old male bear (No. 149) traveled from a 20 August 1978 capture site at Halferty Creek south about 20 km to the Kings Bays watershed where he denned. After emergence the next spring, the bear was located on an avalanche slide several km north of the Halferty Creek capture site where he was killed by a hunter 14 June 1979. The range of this individual covered about 100 km^2 for the interval of time he was monitored.

Fig. 7. Radio-relocations (dots), capture sites (stars), den sites (squares) and ranges for 3 radio-collared female black bears (137, 141 and 147) which exhibited a communal range relationship in northwestern Prince William Sound, Alaska. (Darkened areas = glaciers.)

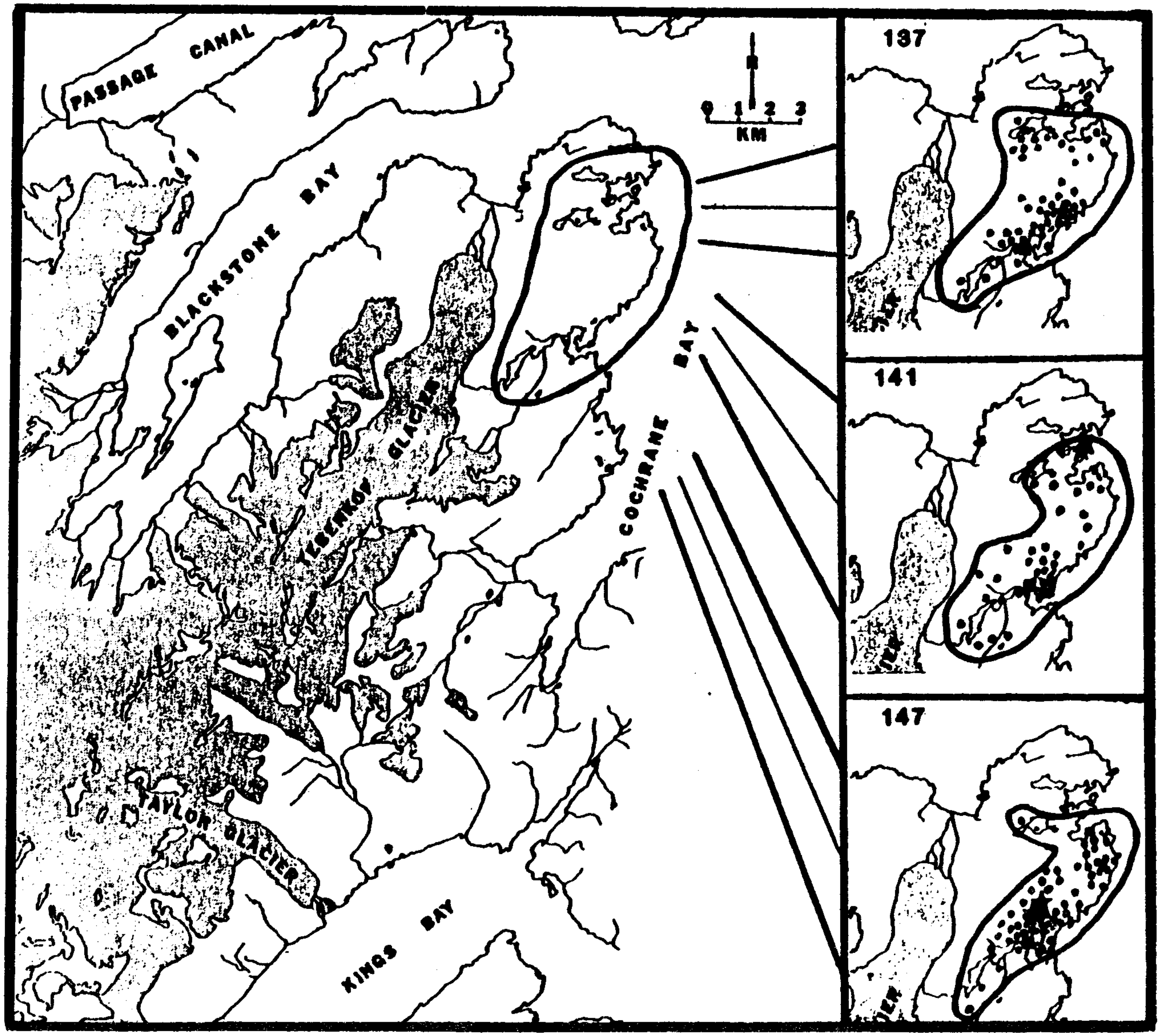


Fig. 8. Size and spatial arrangement of ranges for 11 radio-collared female black bears overlapping in northwestern Prince William Sound, Alaska. (Stars = den sites, other symbols = radio-relocation sites and darkened areas = glaciers.)

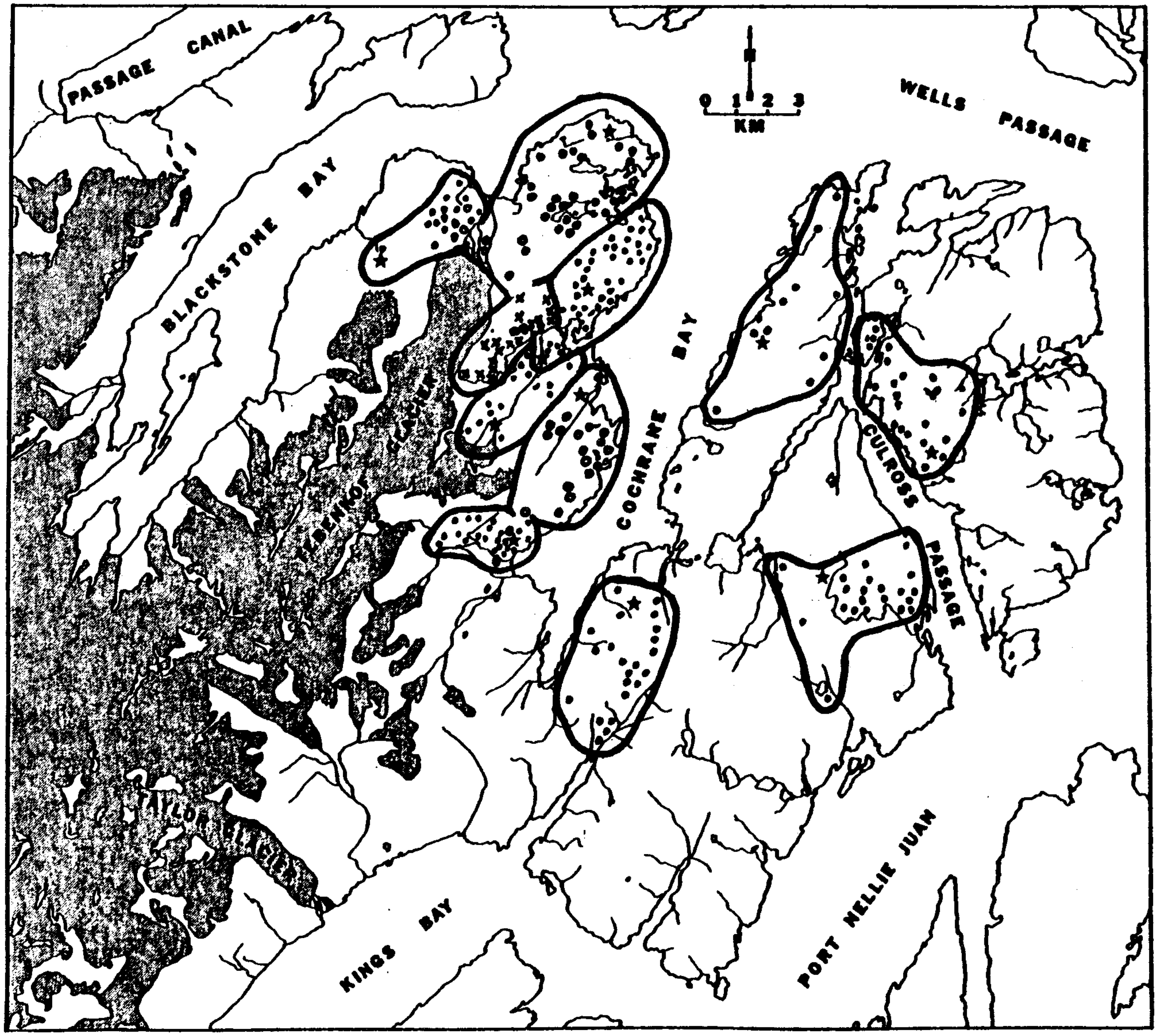


Fig. 9. Capture sites (squares), den sites (stars), kill site (circle) and radio-relocation sites (dots) for 4 radio-collared male black bears (149, 166, 171 and 119) which exhibited relatively extensive movements and large ranges in northwestern Prince William Sound, Alaska. (Darkened areas = glaciers.)

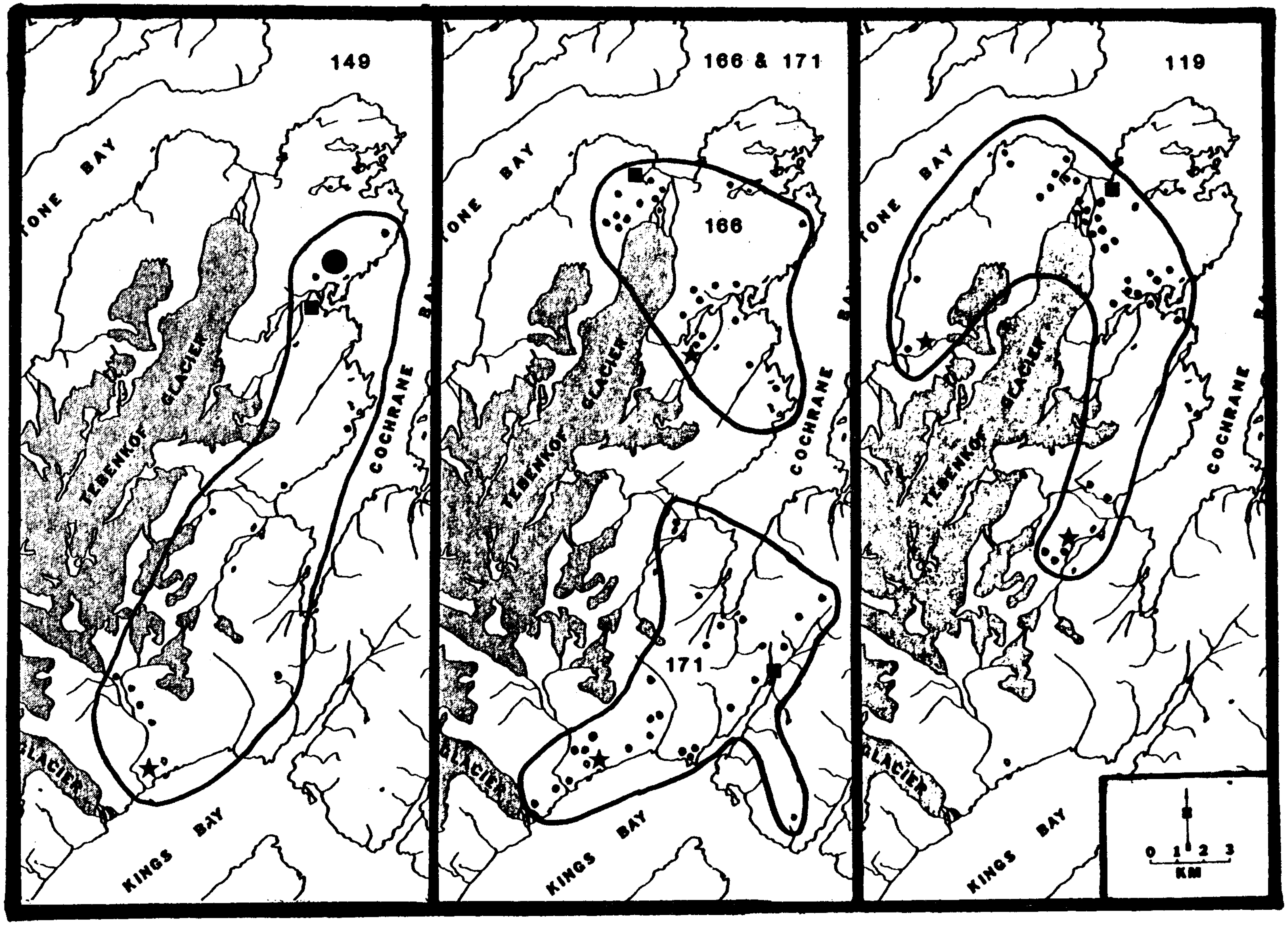
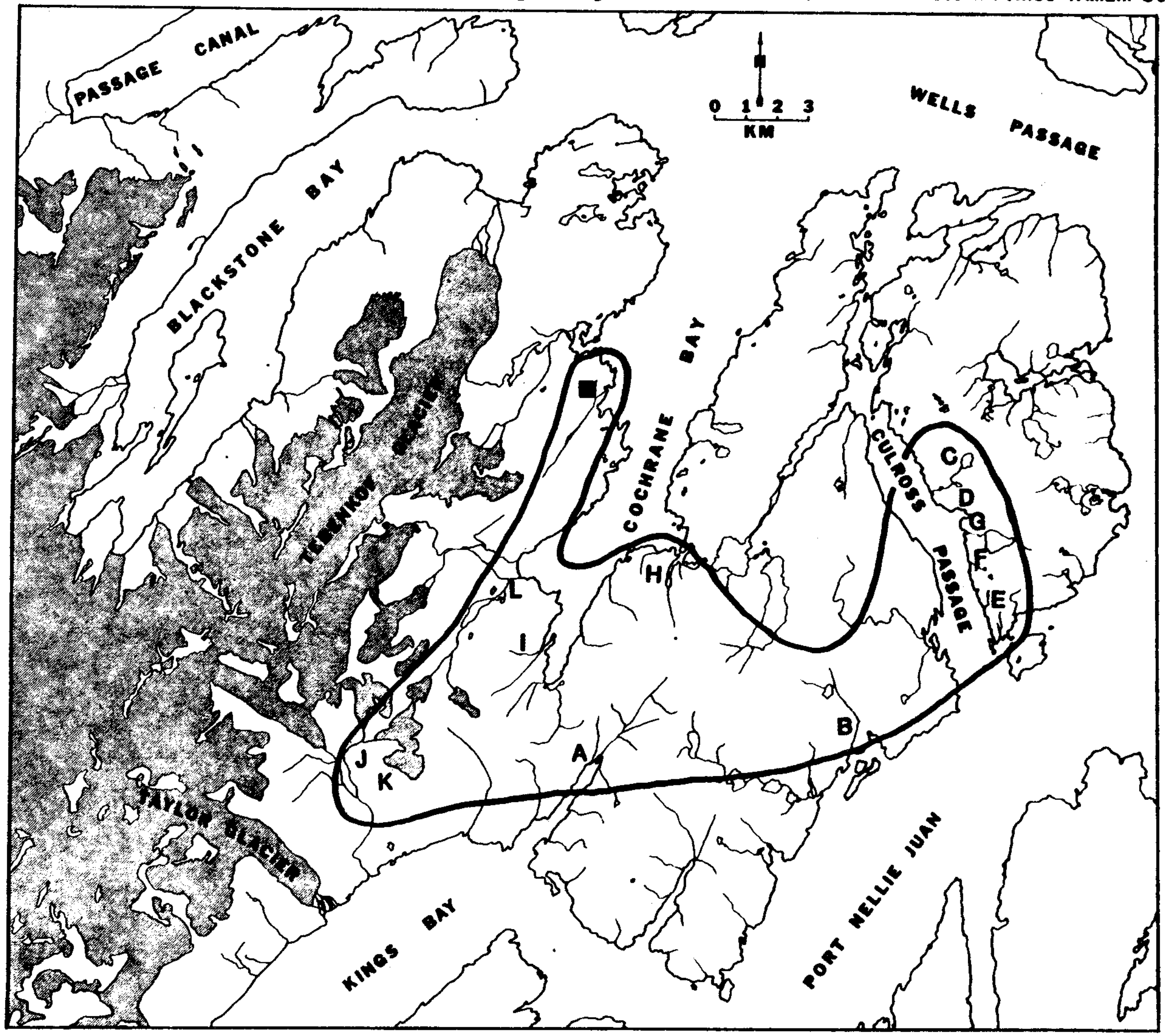


Fig. 10. Sequential relocations (letters) for a male black bear (163) captured and radio-collared at Paulson Creek (square) 17 August 1979 and radio-located through 1 August 1979 (location L) in northwestern Prince William Sound, Alaska.



Similarly, another 3-year-old male bear (No. 119) was found to range over about 100 km^2 and traveled 25 km between consecutive den sites during the 1½-year period he was monitored.

Two male bears, No. 166 (6 years old) and No. 171 (8 years old) which were captured in spring 1980 and monitored for 1 year, ranged over about 70 and 85 km^2, respectively during that time period. These data may indicate that adult males are more settled and may occupy slightly smaller ranges than immature males.

However, 1 male bear (No. 163), captured and radio-collared 17 August 1979 at Paulson Creek and estimated to be over 6 years old, traveled extensively during the subsequent year. After capture, this individual traveled about 15 km south to West Finger Inlet in Kings Bay watershed, then about 10 km east to the Port Nellie Juan watershed, then northeast 10 km across Culcross Passage and onto Culcross Island where he traveled another 10 km before denning. The following spring, this individual again crossed Culross Passage as he was subsequently relocated about 11 km east of the den site near Three Finger Bay, a side branch of southeastern Cochrane Bay, from where he traveled 12 km southwest to near Cotterell Glacier and then 7 km north to Parks Creek where he was last located on 1 August 1980. This individual had traveled a minimum of 75 km, encompassing a range of roughly 140 km^2 during that year.

Extraordinary Movements

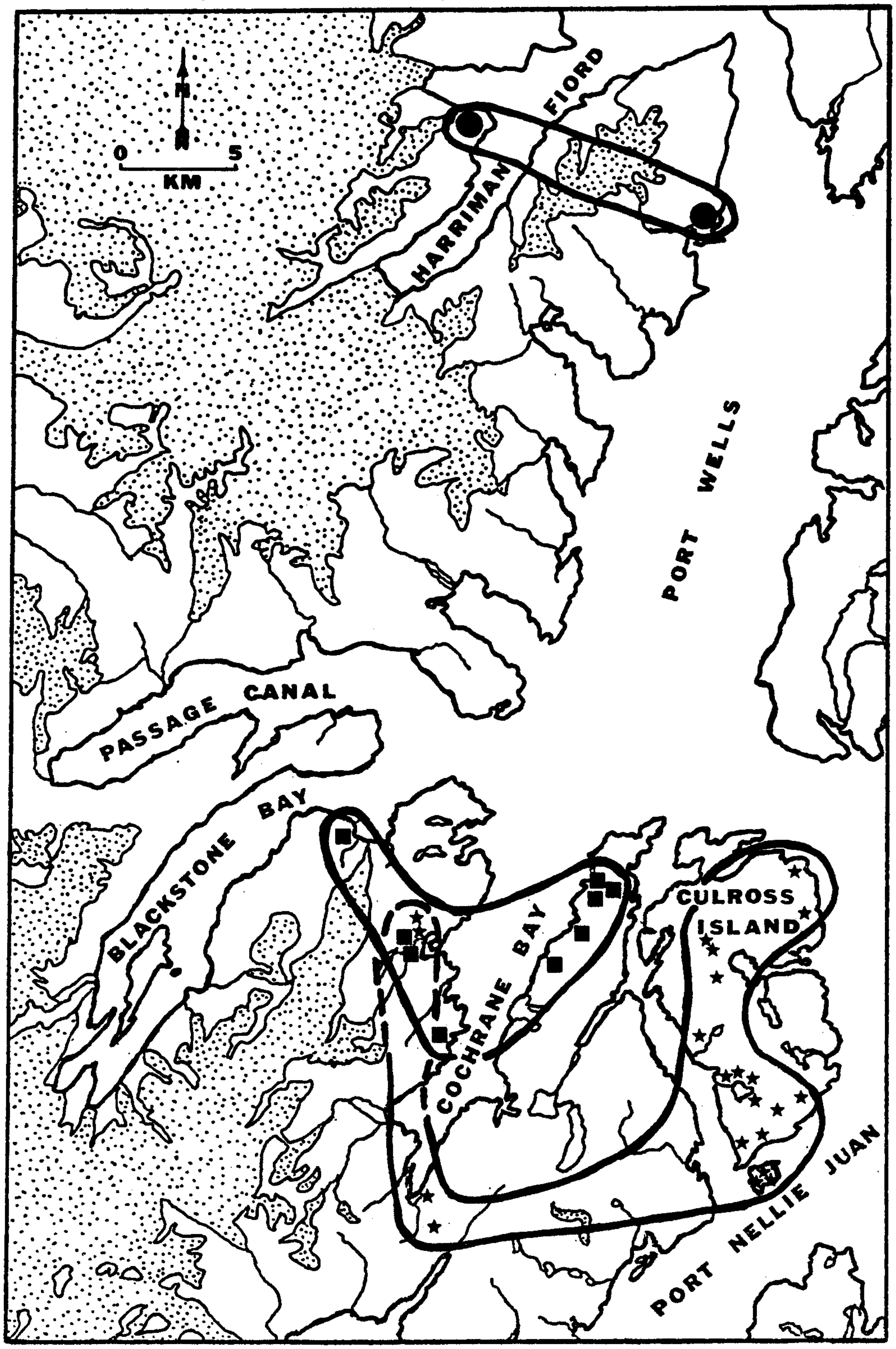
Movements by radio-collared male bears No. 102 and 163 and female bear No. 159 indicate that "physical obstacles" as glaciers and/or large bodies of saltwater are not barriers to movements (Fig. 11).

Male No. 103, captured in 1976 as a 2-year-old at Harrison Lagoon, was subsequently killed about 10 km to the northeast by a hunter in spring 1978. Though the straightline distance traversed was not great, the bear had crossed at least 2 km of rugged glacier or swam a similar distance in iceberg-laden saltwater to arrive at the kill site.

Male bear No. 163, captured at Paulson Creek in summer 1979 and estimated to be over 6 years old, moved north to Halferty Creek in late summer and then traveled south and east and across a body of water about 32 km to Culross Island where he denned in winter and continued to range over the island the following spring and early summer.

A 4-year-old female, No. 159, made an extensive late summer movement from Tebenkof Creek, to Halferty Creek, to a point south of Paulson Creek, and then across or around Cockrane Bay to its northeastern shore where she denned (a straightline distance of 5 or an overland journey of 30 km). In either case, an extraordinary movement for a mature female.

Fig. 11. Radio-relocations (symbols) and ranges for 3 black bears, 103 (circles), 159 (squares) and 163 (stars), which exhibited extraordinary movements in northwestern Prince William Sound, Alaska. (Stipled area = glaciers.)



Home Range and Density

Sizes of ranges for male black bears studied in Prince William Sound were not greatly different from those determined for male bears in Idaho (Amstrup and Beecham 1976) and on the Kenai Peninsula, Alaska (Schwartz and Franzmann 1981), 70-100 km^2, 112 km^2, and 98 km^2, respectively. But they are considerably smaller than the 234 km^2 ranges reported for male black bears along the upper Susitna River, Alaska (Miller and McAllister 1982) and considerably larger than the 52 and 5 km^2 ranges reported by Poelker and Hartwell (1973) and Lindzey and Meslow (1977b), respectively for male bears in Washington.

Sizes of ranges for female bears in Prince William Sound were found to vary from about 10 to 30 km^2, excluding 1 female which ranged over about 75 km^2. These ranges were similar in size to the 16.8 km^2 average recorded by Schwartz and Franzmann (1981) for female black bears on the Kenai Peninsula, Alaska but were considerably smaller than the 200 km^2 range determined for females along the upper Susitna River (Miller and McAllister 1982). In Idaho, Amstrup and Beecham (1976) found ranges for females to average 34 km^2, with the exception of 1 female which ranged over about 130 km^2. In Washington, females were found to range over 4 and 2.4 km^2 in studies by Poelker and Hartwell (1973) and Lindzey and Meslow (1976b), respectively.

Variation in range size due to sex is common to all cited studies; males ranged over larger areas than females. Perhaps this difference in behavior can mostly be attributed to the polygamous breeding strategy of male black bears. No matter how large female ranges are, the ranges of males will be larger. Since natural selection would tend to favor males which inseminate as many females as economically feasible, it would be adaptive for males to range over and become familiar with an area which overlapped ranges of many females and to be aware of the local areas which those females frequented during the breeding season.

Female bears, on the other hand, need only be familiar with a parcel of ground large enough for "self maintenance and development of young" (Amstrup and Beecham 1976:345), but this parcel should ideally be located where male bears are likely to range during the breeding season.

Size of ranges for females will reflect quality of their habitat smaller-sized ranges characterizing preferred habitats. This rationale may not necessarily apply to males, since those which range over the largest area may be favored through natural selection because they would probably also have opportunities to inseminate more different females than would sedentary males, assuming those females also occupied the most "favorable habitats."

In other words, male fitness is maximized by not only inseminating many females but also perhaps more importantly inseminating those females which occupy the highest quality "female" habitat. Perhaps "fit" males key into high-quality "female" habitat and range over such areas for the opportunity to mate with tenant females.

Considering this reasoning, marine coastal habitat in Prince William Sound is similar in quality for females to that on the Kenai Peninsula and in Idaho, but better than that along the upper Susitna River and of considerably lower quality than that found in Washington.

Because ranges within and between sexes of black bears overlap, values for density cannot be directly extrapolated from values for home range size. Except for islands, such estimates may be gross oversimplifications at best.

If I consider only those bears captured in summer along 4 streams which contained spawning salmon (Blackstone Creek, Tebenkof Creek, Paulson Creek, and Halferty Creek), back dated the age of each individual to 1976, and assumed that all individuals used the same area in that year, these data would indicate that at least 19 females, 8 males, and 2 cubs used the 70 km^2 portion of the Tebenkof Peninsula north of Paulson Creek. Disregarding the 10^2 of permanent icefield within the area, these data imply that the area provided habitat for at least 29 different bears. If equally, but unrealistically, divided on a per bear basis, densities of bears in that area would be approximately 1 bear/2.4 km^2 of available habitat. Excluding glaciated habitat, densities calculated for this area in northwestern Prince William Sound would approach 1 bear/2 km^2.

However, it is not unrealistic that densities of black bears in Prince William Sound are equivalent to or greater than those in most areas of North America because: 1) the dense coastal coniferous forests are interspersed with numerous open meadows which contain a lush growth of grasses, herbs, and berry-producing shrubs; 2) perennial snow avalanches maintain numerous slopes in early successional, subclimax vegetative stages rich in grasses, herbs, and berry-producing shrubs and result in locally decreased snow depths which enable the areas to become snowfree exceedingly early in the spring and provide bears with excellent forage; 3) an abundance of cranberries, salmonberries, and blueberries in the area provide excellent forage during summer and early fall; 4) runs of spawning salmon in most of the streams in the area provide bears with an optional food source in summer or an alternate food source should there be a poor berry crop; 5) in western Prince William Sound, the essential absence of ungulates and brown bears eliminates most interspecific competition for food or space; 6) large grass and sedge flats on glacial and stream tidal deltas provide ideal foraging conditions in spring; 7) the mosaic character and interspersion of habitat types is ideally accentuated by numerous narrow fiords, streams, and glaciers; 8) although winters in the area are relatively cold and long and denning periods extend approximately 6-7 months, a deep snowpack common to the area may ameliorate the expectations of poor wintering conditions; 9) the microclimatic effect of topography (slope and aspect) and snowpack on plant phenology creates a temporarily protracted period in which vegetation at any given stage of growth will be available to bears; and 10) preliminary field data which indicate that bears in the area may be relatively small in size, in comparison to those of more southerly populations, may in part contribute to and account for greater densities even at similar food bases. Overall, ecological conditions for black bears in GMU 6 and particularly in northwestern Prince William Sound appear to be excellent, and, although individually the bears may be small in size, it is not unreasonable to believe that population densities of 1 bear/200 ha occur.

Marked Bears Killed by Hunters

Data collected on the fate of marked and released black bears provide information on overall and sex-specific hunter-kill mortality rates for bears occupying the study area.

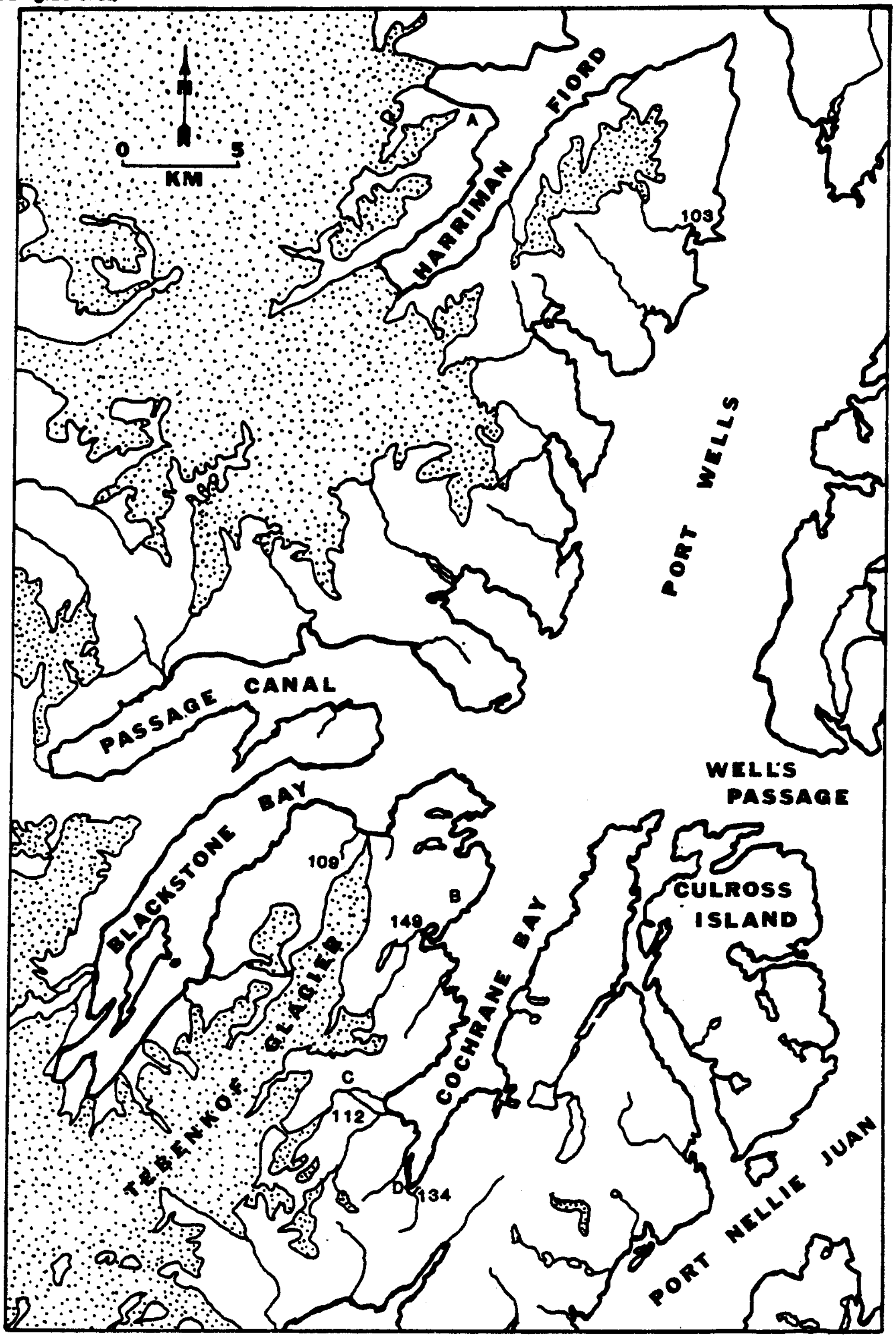
From the 1976 summer field season through the 1981 hunting season, 25 female (deleting the 2 known mortalities) and 14 male bears were captured, marked, and released. During this interval, hunters reported killing 5 of the marked bears; all were males. Four of the bears were killed in Cochrane Bay, an area intensively studied throughout the project, and 1 bear was killed in Harriman Fiord (Fig. 12). Kill sites were near and far from where the individuals were most recently captured, and time intervals between capture and kill also varied greatly. Individual No. 134 was killed less than 1 month after his capture, No. 149 was killed less than 1 year after capture, No. 103 was killed less than 2 years after capture, and No. 109 and 112 were killed less than 4 years after their initial capture but less than 1 month after their latest capture.

Three of the bears, No. 109, 112, and 134, were killed by members within the same hunting group. In a previous year, bear No. 149 had also been killed by a member of that same group.

Between the time of release through the 1981 hunting season, the 25 marked females were available to be killed by hunters a total of 83 female bear-seasons (no. female bears x no. seasons available). During this interval, none of the marked females were known to be killed by hunters. These data imply that less than 1.2% (<1 of 83) of the female bears available to hunters are killed.

By the end of the 1981 hunting season, 5 of the 14 marked and released male bears were reported killed by hunters. These 5 bears were killed out of 40 male bear-seasons of availability through the 1981 hunting season. These data imply that about 13%

Fig. 12. Locations where 5 captured and marked male black bears were subsequently killed by hunters in northwestern Prince William Sound, Alaska. (A=5 May, 1978 kill site for bear 103, captured 31 July, 1976 at site 103. B=28 May, 1978 kill site for bear 149, captured 20 August, 1977 at site 149. C=7 and 8 June, 1980 kill site for bears 112 and 109, captured 22 May, 1980 at sites 112 and 109, respectively. D=7 June, 1980 kill site for bear 134, captured 22 May, 1980 at site 134. Stipled area=glaciers.)



(1 of 8) of the male bears available to hunters each season are killed and that the probability of a male bear being killed is 10 times greater than that for a female bear.

Hunters killed marked bears at a rate of 4 per 123 bear-seasons of availability, or 4% of the bears available to hunters were killed. This rate is apparently strongly related to the sex ratio of bears available.

Chemical Components of Food Items

Chemical analyses indicated great differences in the relative proportions of organic and inorganic constituents within and between the major types of food items available to black bears during spring or summer (Table 11).

For summer food items, notable differences were exhibited in the relative proportions of organics N (N x 6.25 = crude protein), TNC (total nonstructural carbohydrates), and crude fats and inorganics P, Ca, and Na between carcass components of pink salmon and berries.

Within the pink salmon category, substantial differences were found in P, K, Ca, crude fat, water, and total ash between samples from particular carcass components.

Within the berry category, values for cellulose, total ash, Mn, Zn, K, and N were slightly higher in samples of *Rubus* sp. than in samples of *Vaccinium* sp.

Spring food items of black bears generally contained *higher* levels for inorganic constituents total ash, P, K, Ca, Mg, Na, Zn, Fe, Mn, and Cu and except for N contained *lower* levels for organic components of crude fat and TNC than did the summer berries. The N content of vegetative food items was considerably higher in spring food items than in summer food items.

Lignin content of ferns (*Pteridophyta*) was considerably higher than that for other vegetative food items.

Samples of *Carex* sp. collected in tidal marsh habitat contained substantially greater amounts of N and TNC and less water and lignin than samples of *Carex* sp. collected from *Picea* sp.-*Alnus* sp. dominated habitats: 3.58, 14.0, 78.5, and 1.5 vs. 2.90, 9.3, 81.3, and 3.6%, respectively.

Samples of *Calamagrostis* sp. and *Heracleum lanatum* contained relatively high concentrations of N, 6.10 and 8.10%, respectively and relatively low concentrations of lignin, 1.7 and 4.1%, respectively, compared to samples of other summer food items.

Leaf bud spikes of *Veratrum viride* contained relatively high concentrations of N but also exhibited moderately high levels of

Table 11. Chemical composition of food items available to black bears in spring or summer seasons in Northwestern Prince William Sound, Alaska. Composition taken over broad areas.

Season
Species (sampling date)
Item

Summer	N	P	K	Ca	Mg	Na	Zn	Fe	Mn	Cu	Crude fat	TNC	% H_2O	NDF[1]	ADF[1]	Lignin[1]	Cellulose[1]	Hemicellulose[1,2]	Total ash[1]
									CHEMICAL COMPOSITION.										
Pink salmon (20 AUG) (Oncorhynchus gorbuscha)																			
Flesh	13.9	1.7	2.04	0.68	0.10	0.36	0.0039	0.0056	0.0001	0.0001	4.68	6.3	77.5	0.3	0.8	0.6	0.07	0.0	6.7
Eggs	11.8	1.5	0.67	0.14	0.14	0.28	0.0047	0.0048	0.0003	0.0013	15.14	1.1	60.1	29.1	2.5	1.5	0.90	26.6	3.6
Head (includes brain)	11.2	4.0	0.19	1.62	0.04	0.40	0.0118	0.0181	0.0003	0.0004	9.76	2.8	81.7	3.3	1.3	0.9	0.04	2.0	22.8
Berries (20 AUG)																			
Rubus spectabilis	1.42	0.30	0.69	0.07	0.07	0.01	0.0013	0.0050	0.0121	0.0004	7.82	35.8	87.5	19.8	18.6	5.1	13.4	1.2	3.9
Vaccininum sp.	1.29	0.24	0.39	0.08	0.03	0.01	0.0006	0.0030	0.0044	0.0003	6.30	37.9	90.4	18.6	15.6	7.2	0.2	3.0	1.8
Spring																			
Fauria crista-galli (7 JUN)																			
Leaves	3.88	0.42	1.67	0.63	0.19	0.30	0.0085	0.0070	0.1010	0.0008	0.80	17.4	84.2	53.9	15.5	4.4	11.0	38.4	6.5
Stems	1.89	0.29	3.74	0.31	0.15	0.50	0.0058	0.0024	0.0319	0.0007	2.14	10.1	94.7	42.7	32.6	8.8	23.6	10.1	10.5
Rubus spectabilis[3] (7 JUN)																			
Stems, lvs., and flowers	3.52	0.40	1.24	0.37	0.26	0.05	0.0052	0.0081	0.0512	0.0008	1.72	14.2	73.1	19.6	10.8	3.1	7.7	8.8	4.5
Flowers	2.57	0.39	1.74	0.31	0.32	0.04	0.0063	0.0061	0.0448	0.0011	1.36	29.3	76.9	15.6	11.7	3.1	8.5	3.9	0.0
Streptopus amplexifolius (12 JUN)																			
Leaves and fruit	3.68	0.42	4.29	0.51	0.28	0.09	0.0081	0.0072	0.0084	0.0008	4.16	15.3	90.0	30.5	22.3	6.3	15.8	8.2	10.3
Lysichitum americanum (7 JUN)																			
Spadix	3.66	0.50	2.08	1.69	0.34	0.27	0.0088	0.0073	0.0600	0.0018	2.98	13.8	89.0	22.2	18.0	7.5	10.5	4.2	10.6
Leaves	4.98	0.53	3.71	0.90	0.25	0.24	0.0055	0.0079	0.0330	0.0011	3.10	10.7	89.5	19.8	14.9	5.2	9.4	4.5	10.8
Veratrum viride (7 JUN)																			
Bud of leaves	6.80	0.57	2.65	0.16	0.14	0.04	0.0095	0.0102	0.0023	0.0024	3.80	9.8	90.3	45.3	16.5	6.5	9.9	28.8	6.9
Heracleum lanatum[3] (7 JUN)																			
Leaves and stems	8.10	0.84	3.33	0.40	0.24	0.05	0.0092	0.0127	0.0042	0.0010	3.22	7.5	87.6	15.2	12.6	4.1	8.1	2.6	8.6

Table 11. (cont'd)

Season / Species (sampling date) / Item

CHEMICAL COMPOSITION

Spring	N	P	K	Ca	Mg	Na	Zn	Fe	Mn	Cu	Crude fat	TNC	% H_2O	NDF[1]	ADF[1]	Lignin[1]	Cell-ulose[1]	Hemi-cel-lulose[1,2]	Total ash[1]
<u>Angelica lucida</u>																			
Leaves and stems (12 JUN)	4.34	0.42	3.03	0.63	0.24	0.55	0.0074	0.0109	0.0101	0.0006	3.94	9.1	89.2	24.6	22.9	9.5	13.3	1.7	10.6
<u>Ligusticum</u> sp. (12 JUN)																			
Roots	2.50	0.35	2.01	0.70	0.39	0.45	0.0038	0.1740	0.0101	0.0011	1.90	12.0	86.3	40.5	37.6	8.6	25.6	2.9	11.7
<u>Equisetum arvense</u> (12 JUN)																			
Leaves and stems	3.95	0.47	4.37	0.99	0.29	0.06	0.0134	0.0081	0.0061	0.0020	3.08	10.9	87.4	46.4	23.2	6.9	15.3	23.2	13.9
<u>Carex</u> spp. (7 JUN)																			
Leaves, stems and fruit																			
Tidal margin species	3.58	0.37	2.49	0.23	0.16	0.40	0.0051	0.0194	0.0119	0.0007	3.40	14.0	78.5	50.8	20.5	1.5	18.4	30.3	7.8
Woodland species	2.90	0.39	3.26	0.15	0.15	0.35	0.0054	0.0059	0.0116	0.0010	3.30	9.3	81.3	57.0	25.3	3.6	21.7	31.7	7.8
<u>Calamagrostis</u> sp.[3] (7 JUN)																			
Leaves	6.10	0.56	3.54	0.13	0.14	0.07	0.0085	0.0041	0.0390	0.0018	2.14	7.6	85.1	47.7	21.7	1.7	19.9	26.0	7.8
<u>Elymus arenarius</u> (7 JUN)																			
Leaves	3.51	0.39	2.68	0.14	0.11	0.16	0.0047	0.0069	0.0052	0.0003	2.80	12.4	81.2	56.0	25.0	2.4	22.2	31.0	7.2
Ferns (7 JUN)																			
<u>Athyrium</u> sp.	4.61	0.57	2.83	0.46	0.34	0.03	0.0081	0.0057	0.0013	0.0018	1.96	6.9	87.7	55.9	30.8	19.3	11.4	25.1	7.4
<u>Cystopteris</u> sp.	4.00	0.47	3.25	0.16	0.23	0.05	0.0043	0.0071	0.0071	0.0002	4.98	7.7	85.6	45.6	27.1	11.4	14.8	18.5	11.0
<u>Blechum</u> sp.	1.46	0.14	1.51	0.56	0.55	0.24	0.0037	0.0093	0.0200	0.0001	0.01	12.9	74.5	58.8	44.5	18.2	20.8	14.3	7.8
<u>Vaccinium</u> sp. (7 JUN)																			
Leaves and flower buds	3.72	0.51	1.16	0.27	0.16	0.04	0.0073	0.0063	0.0103	0.0015	2.60	14.2	80.1	46.6	22.3	11.4	10.8	24.3	4.4

[1] Calculated as a percent of dry matter.
[2] Hemicellulose estimated, NDF - ADF = Hemicellulose
[3] Samples obtained from mid elevations in avalanche tracts.

Table 11. (cont'd)
Season
Species (sampling date)
Item

CHEMICAL COMPOSITION

Spring	N	P	K	Ca	Mg	Na	Zn	Fe	Mn	Cu	Crude fat	TNC	% H_2O	NDF[1]	ADF[1]	Lignin[1]	Cell-ulose[1]	Hemi-cel-lulose[1,2]	Total ash[1]
<u>Angelica lucida</u>																			
Leaves and stems (12 JUN)	4.34	0.42	3.03	0.63	0.24	0.55	0.0074	0.0109	0.0101	0.0006	3.94	9.1	89.2	24.6	22.9	9.5	13.3	1.7	10.6
<u>Ligusticum</u> sp. (12 JUN)																			
Roots	2.50	0.35	2.01	0.70	0.39	0.45	0.0038	0.1740	0.0101	0.0011	1.90	12.0	86.3	40.5	37.6	8.6	25.6	2.9	11.7
<u>Equisetum arvense</u> (12 JUN)																			
Leaves and stems	3.95	0.47	4.37	0.99	0.29	0.06	0.0134	0.0081	0.0061	0.0020	3.08	10.9	87.4	46.4	23.2	6.9	15.3	23.2	13.9
<u>Carex</u> spp. (7 JUN)																			
Leaves, stems and fruit																			
Tidal margin species	3.58	0.37	2.49	0.23	0.16	0.40	0.0051	0.0194	0.0119	0.0007	3.40	14.0	78.5	50.8	20.5	1.5	18.4	30.3	7.8
Woodland species	2.90	0.39	3.26	0.15	0.15	0.35	0.0054	0.0059	0.0116	0.0010	3.30	9.3	81.3	57.0	25.3	3.6	21.7	31.7	7.8
<u>Calamagrostis</u> sp.[3] (7 JUN)																			
Leaves	6.10	0.56	3.54	0.13	0.14	0.07	0.0085	0.0041	0.0390	0.0018	2.14	7.6	85.1	47.7	21.7	1.7	19.9	26.0	7.8
<u>Elymus arenarius</u> (7 JUN)																			
Leaves	3.51	0.39	2.68	0.14	0.11	0.16	0.0047	0.0069	0.0052	0.0003	2.80	12.4	81.2	56.0	25.0	2.4	22.2	31.0	7.2
Ferns (7 JUN)																			
<u>Athyrium</u> sp.	4.61	0.57	2.83	0.46	0.34	0.03	0.0081	0.0057	0.0013	0.0018	1.96	6.9	87.7	55.9	30.8	19.3	11.4	25.1	7.4
<u>Cystopteris</u> sp.	4.00	0.47	3.25	0.16	0.23	0.05	0.0043	0.0071	0.0071	0.0002	4.98	7.7	85.6	45.6	27.1	11.4	14.8	18.5	11.0
<u>Blechum</u> sp.	1.46	0.14	1.51	0.56	0.55	0.24	0.0037	0.0093	0.0200	0.0001	0.01	12.9	74.5	58.8	44.5	18.2	20.8	14.3	7.8
<u>Vaccinium</u> sp. (7 JUN)																			
Leaves and flower buds	3.72	0.51	1.16	0.27	0.16	0.04	0.0073	0.0063	0.0103	0.0015	2.60	14.2	80.1	46.6	22.3	11.4	10.8	24.3	4.4

[1] Calculated as a percent of dry matter.
[2] Hemicellulose estimated, NDF - ADF = Hemicellulose
[3] Samples obtained from mid elevations in avalanche tracts.

lignin, 6.8 and 6.5%, respectively. This plant is also known to contain an alkaloid toxic to humans.

Samples of Rubus spectabilis stems, leaves, and flowers contained relatively high concentrations of TNC and relatively low amounts of water and lignin.

Except for extremely high values for Ca and relatively high valuses for Mn, chemical attributes for Lysichiton americanum were similar to those of other vegetative food items.

Ligusticum sp. roots contained extremely high levels of Fe and cellulose; values for other components were not outstanding.

Samples of Equisetum sp. contained extremely high levels of K and Zn, high levels of Ca, and moderate levels of N, crude fat, TNC, water, and lignin.

DISCUSSION

Live Capture Sampling

Data presented indicate that foot snares can be a useful technique for capturing black bears in coastal habitats in summer when placed on trails along streams containing spawning salmon. Benefits of using foot snares are low cost, light weight, and ease in which they may be placed or moved from 1 location to another. Efficiency in using foot snares decreases greatly when few bears are feeding on salmon, trails are not well defined, and when specific location of fish in streams changes with water conditions; in either case, deciding where to place snares becomes difficult. In some instances, due to arrangement of vegetation, snares could not always conveniently be placed where activity of bears dictated.

Barrel-type live traps appeared to be more efficient in capturing bears than foot snares. This was particularly the case when few bears were feeding on salmon and traps could be placed wherever desired along a stream. Barrel-type traps are difficult and clumsy to transport to or between trapping sites, and many stress bears during hot or wet, cold weather. The latter is particularly critical when traps may not be tended every day. I believe that our 1 trap mortality was the result of the bear getting wet and cold in the trap and becoming hypothermic while inclement weather prevented me from tending traps. Though cubs were captured in foot snares, I believe barrel-type would be more efficient in capturing cubs and very young or small individuals.

Both methods of live capture sampling tested in areas near streams containing spawning salmon were entirely dependent on the salmon food source attracting bears to those areas. Data collection in 1975 (when there was a poor salmon run) and in 1978 and 1979 (when good numbers of salmon were available to bears) indicate that bears may not be attracted to streamside areas to feed on spawning salmon if berries are locally abundant. Trapping success can be highly variable from year to year.

However, even when numerous bears were in streamside areas and some were captured, data collected indicate that samples from these areas may be biased toward females and females with cubs. Within the male sample, few adults were captured with the trapping techniques employed.

Since salmon spawning runs did not occur on the west side of the Tebenkof Peninsula, bears occupying those areas were likely to have lower probabilities of being sampled than bears which occupied areas on the east side of the peninsula where streams which contained spawning salmon were common, unless all bears traveled to feed on spawning salmon in summer regardless of the distance between their range and the food source.

I attempted to investigate this contention in July 1978 by using bait with foot snares placed in areas which lacked streams with salmon runs. This capture technique was a failure; no bears were captured and no bear signs were even observed around the bait.

In summary, major findings learned in this study regarding the practicality and feasibility of obtaining a representative live sample of black bears from a coastal population by trapping along streams containing spawning salmon are the following: 1) bears do not necessarily visit streams which contain spawning salmon every year; 2) bears do not necessarily gather at the same streams each year; 3) bears seem to congregate at a particular stream in a given year; 4) streams with seasonally early, good and long, annually consistent, and readily available runs of salmon may fail to attract many bears in any year; 5) samples of bears may be biased towards females; 6) samples of male bears may be biased toward younger individuals; 7) samples may be generally biased toward individual bears which have ranges adjacent to salmon streams; and 8) attracting and capturing bears with baited snare sets placed in areas which lacked salmon streams was ineffective.

Data presented indicate that male black bears may be captured in spring with bait in barrel-type live traps placed in grass/sedge flats near high tide line. Only 1 bear was captured with this technique, and it appeared that considerable effort would be required to capture bears in this manner. However, this technique would be useful in capturing the adult male segment in a coastal bear population.

Data gathered in spring 1980 indicated that by far the most desirable method of capturing a representative live sample of black bears in a coastal area was locating individuals with a fixed-wing aircraft and immobilizing them with tranquilizers administered by personnel aboard a hovering helicopter. This technique was highly efficient and appeared to be nonselective for sex or age classes of bears. In fact, there is latitude in selecting a particular segment of the population to be captured. This technique was particularly successful in early spring when most of the substrate was snowcovered and before deciduous vegetation had leafed out; bears were highly visible and could be herded with the helicopter to keep them out of dense coniferous forests before they became immobile.

Movement Patterns, Behavior, Habitat Use, and Food Habits

Annual activities of black bears revolve around accomplishing the following life history details: 1) preparing for hibernation; 2) hibernating; 3) recovering body condition lost during hibernation; 4) preparing for breeding; 5) breeding; and 6) again, preparing for hibernation. For females, activities of bearing and raising young must be superimposed on those listed. The following account provides commentary and biological justification for those activities observed with black bears in northwestern Prince William Sound.

Shortly after bears were captured and radio-collared in August 1977, most dispersed from the salmon spawning streams. Field observations and data on success rates of snaring indicated that more bears were present at the streams during the 2nd and 3rd weeks of August than during the 1st or 4th weeks, though substantial numbers of fish were available from late July to early September.

Although most bears stopped feeding on salmon before the end of August, they remained for several more weeks at mid-to-lower elevations, where observed fresh scats indicated that salmonberries continued to be a major dietary constituent and blueberries probably supplanted salmon as the other staple. Similarly, in other studies, brown (Troyer and Hensel 1964:771, Clark 1957:146) and black (McIlroy 1972:35) bears have been reported to shun a readily available salmon food source for vegetative foods.

Sometime in September, bears moved from lower elevations to alpine areas where blueberries probably became the dominant dietary item, as is usually the case in most interior areas of Alaska (Chatelain 1950, Hatler 1972). McIlroy (1972) reported that black bears in eastern Prince William Sound did not move to alpine areas to feed on blueberries, but instead bears remained in forested habitat where *Vaccinium* sp. was prominent in the understory. The observation of 5 single bears on 2 October 1977 in alpine areas (at about 500 to 800 m elevation) supports the previous contention for northwestern Prince William Sound.

Bears probably continued to feed on blueberries during most of September and into October. During this period, the immature male bears especially appeared to be quite mobile. By the last week of October, most bears had ceased traveling and had probably selected a den site. Radio-tracking data strongly indicated that all bears were in hibernation at the time of the 2 November tracking flight.

Extensive movements which occurred prior to denning may, in part, be attributed to 1 or several of the following: searches for a den site, movements to a preselected den site, movements to new feeding areas, emigration from a natal area (immature), and/or territorial reconnaissance (adults, particularly males).

Most bears remained in their dens or at least were very sedentary until mid-April. Information on denning and den sites for black bears in northwestern Prince William Sound was gathered subsequently to this study and is presented in Appendix C. Radio-relocating data indicated that bears departed from their denning areas between 19 April and 3 May 1977.

By 3 May 1977, the snowline had receded altitudinally to about 500 ft on the south- and east-facing slopes but was still down to the tideline on north- and west-facing slopes. Very early warm spring weather initiated the melting of snow, and vegetation on the southeast-facing slide areas was growing ("greening up") by 15 May. This was early compared to vegetation in the beach fringe areas which did not appear green until 23 May. At this same date, snow was still at the tideline on north slopes but had receded to 300-500 m on some south-slope slide areas where alders (*Alnus* sp.) were obviously already "leafing out."

Success of black bear hunters in western Prince William Sound is usually best from mid-May through mid-June, a time period when bears forage in beach fringe areas and are extremely vulnerable to boat-transported hunters. Data presented for bears captured in spring 1980 and those killed by hunters 1973-80 indicate that males in particular utilize this habitat.

Information from relocations of radio-collared female black bears indicated that they almost never visited shoreline areas in early spring, but instead were usually located on south- or east-facing avalanche slopes at 100-300 m elevation. It appears that these individuals remained in similar habitat through June.

In early spring, female bears were primarily found on avalanche slopes and males in beach fringe areas, but it is not known which habitat, if either, is "preferred" and whether males preclude females' use of lowland beach fringe habitats or that females preclude males from using mid-elevation snow slide habitat.

Though data available on male bears, particularly, adults, in this study are limited, theory and circumstantial evidence

Evidence indicates that breeding activities in northwestern Prince William Sound probably start in some years by the middle of May and continue through June, when and while most female bears remain and forage in these mid-elevation snowslide areas.

On 14 May, a large bear was observed following the tracks in snow of a radio-collared female bear; presumably, this was a male following an estrous female. Rogers (1977) has reported that during the breeding season, males locate females by following scent trails. On 26 May 1981, 2 radio-collared bears were observed in association with other bears. In 1 instance, numerous "chases, playing, and possible mountings" were observed. On 19 June 1981, 3 different individual bears were observed in the company of other bears. One of these associations was also characterized by chasing, playing, and attempted mountings.

Logically, I would not expect a male to travel through the same area in 2 consecutive breeding seasons, unless he was unsuccessful in breeding all available females or unless males revisit the same females each year to make certain none have lost their young and are again in estrus.

Prior to mid-June, bears probably feed mostly on grasses (*Calamagrostis* sp.), horsetail (*Equisetum* sp.), sedges (*Carex* sp.), cabbage (*Lysichiton* sp.), and ferns (*Polypodiaceae*). Although these items may persist in the diet, field observations indicate that by mid-June and into July, bears are at mid-elevations where *Fauria crista-galli* and salmonberries probably become dietary staples (McIlroy 1970). This contention is further supported by the fact that from 18-29 July 1976, a total of 130 trap nights at baited sets along near tidelines was ineffective in capturing or attracting a single bear (Modafferi 1978*b*). Apparently, bears were "content" at higher elevations and were not actively utilizing or seeking food sources available in the beach fringe areas.

Fauria and *Rubus* probably do not decline in importance as a food source *even with* the arrival and availability of spawning salmon in late July, as it was not until the 1st week of August that most bears appeared to gather at streams containing spawning salmon. Though salmon were available through August and into early September, most bears appeared to have left the streams by late August and started to feed on blueberries. If this is true, bears probably leave salmon streams as soon as berries become palatable and available in adequate quantity. The small amount of data presently available indicates that most bears only actively seek out and feed on spawning salmon when berries are not available. This hypothesis can be justified with the following logic. Bears generally emerge from their dens in spring with enough fat to maintain themselves for several weeks, should they be confronted with inclement spring weather and unavailability of food. During this period, the bears must locate an adequate food source to replace body condition lost during hibernation, to provide for body growth, and to prepare combine to provide a hypothetical sketch describing their movements and the motivation behind them.

After emerging from dens in late April, males must be compelled to seek out and locate a source of nourishment to regain body condition lost through the winter and to prepare themselves for the rigors of a polygamous breeding strategy.

However, during this same critical period, lactating females with young must be more stessed than males for a high-quality food source and probably occupy the highest quality spring habitat and exclude males. Males, on the other hand, which are more mobile and probably subdominant to females with cubs, avoid the latter and their habitats (Rogers 1977). Males seek out beach fringe areas near tideline where, even following the worse winters, high spring tides have melted back the shoreline snow and ice, exposing sedges and grasses and promoting their early vegetative regrowth.

Marine life may also provide food for male bears which visit tidewater areas in spring. Bears have been observed by hunters at low tide feeding on mussels (*Mytilus* sp.), and it is possible bears could search the tidewater margin for marine mammal or fish carrion, though I have never observed either in northwestern Prince William Sound during the spring season.

Rogers (1977) presented evidence that outside the mating season males avoided territories of females, and Atwell et al. (1977) reported concentrations of brown bear sows with cubs in spring in areas where preferred forage was found.

Similarly, female black bears in Prince William Sound, most probably those with cubs, may preclude males from utilizing mid-elevation south-facing avalanche slopes through May. Together these behaviors would enable gravid females, which denned near snow-slide areas, to remain relatively sedentary after emergence with newly born cubs and yet still have immediate access to a highly nutritious food source.

Male bears probably remain in lowland beach fringe habitats on the periphery of female territories until their body condition is replenished or, more likely, until females begin to come into estrus and accept or permit males to travel throughout mid-elevation habitats. At this time, male bears not only have the opportunity to breed but also to move freely and forage in areas previously dominated by females. Perhaps it is lack of female territoriality as well as the drive of males to locate and inseminate as many females as possible that contribute to frequency and extent of movements by males during the spring. When males make these forays, considerable amounts of snow are still present and may act to "obscure" extensive glaciers and perhaps lessen their "formidable" appearance to bears traveling overland.

physiologically for the breeding season. After the breeding season, bears must again replenish energy and accumulate a quantity of deposit fat to carry them through the next denning period. The highly soluble carbohydrate content of blueberries makes them an ideal prehibernation food source for bears. Though bears are known to gather at streams to feed on spawning salmon, a diet of fish flesh, which is relatively high in protein and low in fats, is not preferred.

Additional evidence indicating that bears require and seek out a food source capable of being readily converted into high-energy depot fat is the fact that even when feeding on spawning salmon they prefer to eat the eggs, head cartilage, and brain (all good sources of fats) and seldom bother to eat the body flesh. This further suggests that bears may only move to salmon spawning streams when the quality (ripeness) or quantity of berries are below a given level.

Hunter Kill Samples: Their Relation to the Live Population and Their Use in Management

In many cases, characteristics of bears which were killed by hunters are the only information available for consideration in making management decisions; however, Caughley (1974) warned that "...age ratios often provide ambiguous information and that their facile interpretation can lead to serious management blunders" and that without support from other demographic data they "...seem to be statistics in search of an application."

A comparison of characteristics of data obtained from the hunter-kill sample of black bears with characteristics of data gathered from samples obtained by live trapping in summer and live capture with a helicopter in spring, in part, verify Caughley's reservations regarding the applicability and practical use of data collected from animals killed by hunters.

The samples of hunter-killed bears indicate that the population of bears is dominated by middle-aged males, the summer live trapping samples indicate that the population is composed predominantly of females with few old males, and the sample live-captured in spring with a helicopter characterizes the population sex and age composition differently from the other 2 sampling methods.

Hunting regulatory laws, which make it illegal to shoot cubs or sows accompanied by cubs, must protect a substantial proportion of females and should greatly skew the kill towards males, especially during a spring season when yearling young as well as cubs would still be accompanying their mother. I suspect most hunters could not distinguish between cub and yearling young and would elect not to shoot at a sow with 1½-year-old young.

Less obvious, but perhaps the most important factor which can influence the "representativeness" of a hunter-killed sample is differential behavior of individual bears related to their sex and/or age class. Though it is not sensible to believe that sex and age classes behave similarly, in many instances, it is difficult to predict how these different behavior patterns influence vulnerability of bears to be captured or killed, without prior knowledge of those specific behavior patterns and how they interface with a particular sampling technique.

Differential behavior between male and female bears and hunting regulatory laws act in concert to increase the probability of male black bears being killed during spring hunting seasons (January-July), cause the sex ratio of the hunter-killed sample to be skewed toward males and result in the sex ratio of the live population to be skewed toward females. Characteristically, unhunted populations of bears have equal sex ratios for adults (Kemp 1972, Beecham 1977); whereas, hunted populations have been reported to contain about 1.5 females/male (Jonkel and Cowan 1971, Lindzey and Meslow 1977a).

In addition to hunting regulations which make it illegal to shoot cub bears or sows accompanied by cubs and differential behavior between the sexes of bears, information collected for hunters indicate that behavioral patterns of the hunters interact with those of bears in a manner to further contribute to the observed sexual disparities in vulnerability.

In spring 1980, 3 of the adult males captured were located not far from high tide line, the area most accessible to and commonly used by boat-transported hunters. Whereas information obtained from radio-relocated females and the locations where individual females were live captured with helicopters in spring 1980 indicate that many were located in areas distant from the tideline. Females, in contrast to males, were more commonly found on avalanche slopes high above tidewater or up river valleys a great distance from the tidal water.

Bunnell and Tait (1977) attributed reported differences in vulnerability between sexes of bears primarily to sex-related differences in home range size and mobility. This rationale, along with a high degree of mobility of hunters in boats, was used to account for sex-related differences in vulnerability reported by McIlroy (1972) for black bears in northeastern Prince William Sound. My data indicate that differential habitat use between sexes of bears, along with techniques used for hunting, made males considerably more vulnerable to hunters. Male bears were found to frequent the same habitats which most hunters used for hunting.

The increasing proportion of female bears that appeared in the hunter kill as the spring season progressed may be the result of increasing numbers of females separating from their yearling young and thereby becoming "fair game" to hunters and/or a gradual breakdown in behavioral differences in habitat selection.

Males may also be killed at a higher rate than females because of their larger body size. If the average male bear is larger than the average female, hunters may not shoot at some females because they may not be large enough. Sizes of bears are very difficult to estimate, so I suspect very few hunters do not shoot at bears because of their apparent small size. However, I know of several hunters who hunt in northwestern Prince William Sound and are patient and experienced enough to select and shoot only very large bears, which most probably are also males.

Data gathered in this study indicate that early emergence from dens, greater mobility, habitat selection, and body size of males, in conjunction with an early spring open hunting season and the type of access, hunting methods, and selection employed by hunters, all tended to increase the within season vulnerability of male bears to hunters.

Knowledge of these factors and their effects are necessary to adequately interpret hunter-kill data and to formulate appropriate strategies for local management of black bears.

Population Identity

Data collected in this study indicate that the extraordinary topographic features common to northwestern Prince William Sound are not barriers to movements of black bears and that integrity and distribution of populations of bears throughout the area are probably not much different from those bear populations in heterogeneous (patchy) terrestrial environments.

The few data available for male bears indicated that they regularly traversed great distances and in the process crossed bodies of saltwater and/or glaciers. Though a much greater body of data was available for female bears, there were only indications but no confirmed cases of their crossing either bodies of saltwater or glaciers. However, such data may merely be the result of the characteristically shorter movements and smaller ranges for females in the area and not because topographic features restricted their movements.

My data indicate that behavior and habitat selection and/or regulatory hunting laws make the female population of bears in this area relatively invulnerable to hunting compared to males. Data gathered indicated that in coastal populations of bears males sustain substantial mortality due to hunting. But males also appear to travel great distances and more freely regardless of topographic features, and heavily hunted local areas could easily be recolonized by males from adjacent lightly hunted habitats.

If movements of males are partly in response to internal population pressures, a general decrease in density of males in an extensive area may lead to a more sedentary existence by males and promote the development of more discrete and isolated population of bears with relatively uncommon genetic pools and little genetic flow between adjacent populations.

If this reasoning applies, populations of black bears in northwestern Prince William Sound may be more vulnerable to general area-wide increases in hunting mortality than to locally concentrated intensive hunting mortality.

Feeding Strategy

It is commonly known and well documented that seasonal changes and annual differences in occurrence (local distribution), abundance (quantity), and quality of major preferred food items coupled with opportunistic feeding habits greatly influence movements of black bears (Jonkel and Cowan 1971, Hatler 1972, Amstrup and Beecham 1976, Lindzey and Meslow 1977b, Rogers 1977). Predictable or unexpected movements frequently occur as a timely response to the abundance of certain high-quality preferred food resources, i.e., grasses, sedges, berries, fruits, most spawning salmon, etc. These movements may be directly to a preferred food source or indirectly to an alternate and less desirable food source if it is determined that the former is of insufficient net quality (quantity and quality).

Movements of the 2nd type, followed by consumption of a less preferred diet, occur only if the preferred food sources are of insufficient quantity or not available at the appropriate time. This may account for the movements of black bears between blueberry and salmonberry patches and pink salmon spawning areas observed in this study and the parallel movements observed for brown bears between elderberry (*Sambucus racemosa pubens*) patches and red salmon (*Oncorhynchus nerka*) spawning areas on Kodiak Island (Clarke 1957). In both cases, it was found that if and when berries became available, most bears discontinued feeding on spawning salmon and departed from streamside areas to feed on berries.

During late summer, bears appear to be selecting a diet relatively high in readily digestible carbohydrates, or secondly fats, at the expense of a diet relatively high in protein. Though such a diet may not be ideal for increasing lean body mass, it would be most favorable for storing energy, as deposit fat in preparation for hibernation. Even when bears do feed on salmon in late summer, they showed preference for parts of fish high in fats: the head cartilage brains, and eggs (Modafferi 1978b, Frame 1974). Bears showed considerably less interest in eating the flesh of spawing fish, which is predominantly protein and extremely low in fats.

However, in contrast, during spring and early summer, bears select foods which are relatively high in protein and relatively low in nonstructural carbohydrates and fats (herbs, grasses, and sedges). A diet relatively high in nitrogen must be important for increasing lean body mass and for overall growth.

Food preference by bears is not solely based on the absolute value of primary chemical constituents. The presence of undesirable secondary compounds should also be considered (Fox 1981).

Skunk cabbage (Lysichiton americanum) is frequently noted as a preferred bear food. However, my casual observations indicate that bears in the study area did not consume "cabbage," though its primary chemical profile was similar to other available foods. In 2 different instances in spring, I have observed sites where bears have apparently broken off numerous newly growing cabbage "bud spikes" and then left them. I assume that secondary compounds in the plant discouraged bears from eating the otherwise acceptable food source. Apparently, skunk cabbage has evolved this mechanism to protect the plants from being consumed by bears. Perhaps when cabbage first emerges it is palatable, but shortly toxic secondary compounds are synthesized and make the plant undesirable to bears. Possibly, in the instances I had observed, the compounds had already been formed and precluded desirability of the plant to bears.

Similarly, the profile of major chemical constituents of Veratrum viride and the fact that it is 1 of the 1st plants to carry on photosynthesis and become available on avalanche slides indicate that it could possibly be utilized as a food by bears. However, in several instances, I have observed that bears feeding in these areas neglected Veratrum and instead consumed grasses. Veratrum veride is known to contain alkaloids poisonous to humans; these same compounds may discourage bears from consuming it.

Bears are known to capitalize on particular phenological growth stages of plants to optimize quality of their diets (Amstrup and Beecham 1976, Mealey 1977, Reynolds and Beecham 1977). They are frequently observed feeding near the edges of melting snowdrifts and snowslides where newly growing succulent vegetation continually becomes available. Bears seldom consume grasses and sedges after the plants have matured and contained large quantities of structural carbohydrates (cellulose and lignin). In early spring, however, when protein levels are relatively high and structural carbohydrates low, these same plants are a preferred food item (Atwell et al. 1977, Mealey 1977).

It is interesting, but not surprising, that berries, a highly ranked bear food, have not evolved a mechanism to prevent bears from feeding on them. Perhaps the evolutionary strategy of berry plants (Vaccinium sp. and Rubus sp. considered here) in northwestern Prince William Sound has been to encourage not discourage use of their fruits by bears as a food source to facilitate dispersal of seeds, ultimately to increase the distribution of those particular species. If this were the case, then the proximate strategy of berry plants would be to produce visually and chemically attractive fruits. Since the digestive strategy of bears is to process a great deal of food inefficiently, rather than efficiently process a much smaller quantity of food, viability of seeds in the berries is probably not altered.

In general, bears probably do not have highly refined digestive mechanisms. They are opportunistic and mobile and can readily travel to locally available sources of easily digestible food material, which they consume in large quantities and process rapidly and inefficiently. As a very generalist omnivore, the black bear is not highly adapted for a particular type of food, but instead maintains the adaptability for a wide spectrum of food regimes.

The Future

Humans and their activities will continually become a more common feature in the environment of black bears in northwestern Prince William Sound.

Northwestern Prince William Sound is an extremely attractive and popular marine recreation area. Because of its proximity to the population centers of Anchorage and the Kenai Peninsula by aircraft and by highway vehicle and boat through the centrally located Port of Whittier, its popularity and use by recreationists will continue to increase in parallel with the human population in adjacent metropolitan areas.

Expansion and development of facilities for recreational participants will no doubt promote additional human use of the area. In 1981, the Whittier small boat harbor was enlarged to accommodate twice as many boats. This convenience alone should nearly double human activities in the area, regardless of local increases in the human population.

Recent construction of several new recreational overnight cabins by the U.S. Forest Service within the Chugach National Forest, along with plans for many more similar facilities will undoubtedly bring about a dramatic increase in public use of the general area and extensive local use of those specific terrestrial sites. In the absence of cabin facilities in the area, I suspect most visitors spend little time on shore utilizing terrestrial habitats.

Availability of permanent cabin facilities may result in desirable and undesirable consequences. In concentrating or localizing human activities, relatively large impacts will be realized in small portions of the habitat. Whereas, without permanent cabin facilities, activities of humans would be locally less pronounced but more spread out over the entire area. In localizing human activities to specific sites over a long period of time, it is possible that black bears will be attracted to those sites and human/black bear confrontations will likely result. Because overnight cabins are conceived and erected to promote recreational use of the area, I suspect these facilities will be constructed in close proximity to streams which support large annual runs of spawning salmon for visitors to observe and/or catch.

However, black bears are attracted to these same streams to feed on spawning salmon. Common use of these areas by recreationists and bears can only result in numerous human/bear confrontations and may lead to dangerous circumstances for children, unsuspecting adults, and people inexperienced in dealing with bears. My data indicate that female bears with young commonly visit these areas to feed on salmon, and their presence alone would lead to very dangerous circumstances for humans in the area.

It is also possible, that increases in human activities in streamside areas may discourage bears from coming to feed on salmon and result in adverse affects on bear populations, particularly in years when berries are not abundant. I recommend that if overnight cabin facilities be erected they be distant from streams which normally contain runs of spawning salmon.

Availability of recreational cabins will result in increasing and concentrating hunting activities and effort in the immediate vicinity of the facilities and will probably result in local decreases in the numbers of bears. Methods or goals for management of black bears in the area may have to be adjusted accordingly.

In view of past trends in the hunter kill and the potential for substantial increases, there will undoubtedly be a continued and more pronounced disparity in the sex ratio of local populations and a further reduction in the proportion of old, adult males in those populations. Hypotheses regarding ultimate impacts of such a hunting kill scenario are varied. Kemp (1972) furnished evidence that the removal of adult black bears resulted in a net increase in the population size, which was attributed to enhanced survivorship of juveniles and subadults. Beecham (1977) found that the density of a heavily hunted black bear population was greater than that for a lightly hunted population, but that productivity was independent of density and a function of habitat quality and the number of females in the population. Beecham (1977:204) clearly stated, "...the game manager cannot expect increased productivity as a compensatory factor resulting from the heavy harvest of a black bear population..." and "...without reservoir areas nearby to produce highly mobile sub-adult bears, heavy hunting pressure can be expected to reduce bear densities."

The findings of Beecham are not contrary to those of Kemp, as the increased juvenile survival documented by Kemp (1972) can be independent of stable productivity levels and still result in population increases. Stringham (1977) believed that available evidence is inadequate to properly evaluate if survivorship or productivity is enhanced in the absence of adult males and raised questions regarding effects and impacts of selective culling by hunting on the genetic constitution of the population (i.e., by selectively removing large, aggressive, and far-ranging adult male bears from the population are only genes for small, submissive, and sedentary males perpetuated) and pointed to the need for data on minimum desirable sex ratios. Bunnell and Tait (1978) pointed out that in some instances impacts of overkill on recruitment may be difficult to detect in kill data and that once realized it may take up to 25 years to reverse population trends induced by overharvest.

I concur with Stringham (1977), in that 1 of the critical questions to be answered for black bears in Prince William Sound is the determination of minimum sex ratios required for maximum reproductive output. I further believe that the ideal sex ratio is, in part, dependent on the age and genetic character of resident adult male bears, which influence their size, aggressiveness, movements and range, knowledge of behavior of tenant females, and performance as sires.

In view of this hypothesis, I recommend additional study on movements and behavior of old, adult male black bears in northwestern Prince William Sound.

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APPENDIX A

Capture information, identification numbers, sex, age, weight (kg) and body measurements (cm) for black bears captured in northwestern Prince William Sound, Alaska, 1976-1980.

Capture information				Number 4/ Ear tag						Body measurements						
													Circumference		Head	
Location 1/	Date	Method[2]	Type[3]	Left	Right	Lip tattoo	Sex/No. cubs	Age/Dam No. 4/	Weight	Total length	Shoulder height	Girth	Foreleg	Neck	Width	Length
TB	7/29/76	S		B101	B102	10A	F	4	79	139	81	96	31	60	16.4	26.5
HL	7/31/76	S		B103	B104	103	M	2	52	129	83	83	28	51	14.4	26.5
TB	8/2/76	S		B106	B105	105	F	14	72	142	79	87	30	56	15.8	24.9
PL	8/3/76	S		B107	B108	107	M	2	41	122	73	75	25	42	13.5	24.7
TB	8/9/76	S		B109	B110	104	M	9	84	143	87	93	29	59	17.3	28.3
TB	9/9/76	S		B111	B112	112	M	2	41	123	67	72	26	42	12.8	23.5
HL	8/10/76	S		B113	B114	113	F	7	54	140	83	81	30	45	14.0	25.2
BK	8/10/76	S		B115	B116	115	F	3	36	115	76	69	23	41	13.5	23.0
TB	8/19/76	S	Rp	B101	B102	10A	-	-	91	--	--	--	--	--	--	--
TB	8/19/76	S		B117	B118	117	F	15	68	146	81	92	30	55	15.3	25.1
BK	8/19/76	S		B119	B120	119	M	2	45	130	75	74	27	47	13.1	24.2
PC	8/22/76	S		B121	B122	121	M	2	57	132	75	82	28	48	14.1	25.0
BK	8/22/76	S		B123	B124	123	F	3	39	123	69	66	25	43	12.5	22.3
BK	8/24/76	S		B125	B126	125	F/2	5	63	146	83	83	28	51	14.7	25.0
TB	8/28/76	S		B127	B128	NA	F	3	41	118	67	74	24	41	12.5	21.9
TB	8/28/76	S		B129	B130	NA	F	12	70	145	76	92	30	54	16.0	25.0
TB	7/25/77	S	Rc	B106	B132	105	F	15	68	144	79	88	29	53	16.0	24.7
TB	8/7/77	S	Rc	B101	B102	10A	F/2	15	5	--	--	--	--	--	--	--
BK	8/13/77	S		B135	B136	135	F	C/B106	12	89	47	49	16	29	9.6	16.7
HF	8/14/77	S	Rc	B119	B139	119	M	3	52	149	82	84	28	50	14.3	25.0
HF	8/14/77	S	Rc	B107	B108	107	M	3	61	132	81	85	29	50	15.5	25.5
HF	8/16/77	S	Rc	B125	B126	125	F	6	67	141	82	86	27	50	14.8	25.5
HF	8/16/77	S		B141	B142	141	F	12	62	141	79	86	28	50	16.0	25.0
HF	8/16/77	S		B143	B144	143	F	16	82	155	85	100	30	59	17.0	26.8
HF	8/17/77	S		B137	B138	137	F	22	77	138	78	95	32	51	15.7	25.5
HF	8/19/77	S		B147	B148	147	F	2	33	104	65	68	23	38	6.7	10.4
HF	8/20/77	S		B149	B150	149	M	3	64	137	81	88	31	47	15.0	25.5
PL	8/24/77	S		B151	B152	151	F	3	43	121	68	76	26	44	13.3	22.8
HF	8/27/77	S		B153	B154	153	M	3	58	134	71	82	29	45	14.0	25.5
TB	8/28/77	S		B155	B156	NA	M	C/B101	18	88	47	56	20	31	10.5	18.5
HF	8/15/78	S		B157	B158	157	F	5	66	156	82	86	27	52	15.0	24.8
BK	8/2/79	T	Rc	B106	B132	106	F/3	17	70	144	78	92	30	49	16.0	24.8
BK	8/2/79	T		B146	B145	NA	F	C/B106	8	67	--	46	27	30	8.3	15.1
TB	8/3/79	T		B159	B160	159	F	5	58	133	76	76	28	52	15.2	25.9
HF	8/11/79	T	Rp	B159	B160	159	-	--	--	--	--	--	--	--	--	--
BK	8/11/79	T	Rp	B146	B145	NA	F	C/B106	10	--	--	--	--	--	9.5	17.5

APPENDIX A (cont'd)

Capture information				Number 4/ Ear tag					Body measurements							
													Circumference		Head	
Location 1/	Date	Method[2]	Type[3]	Left	Right	Lip tattoo	Sex/No. cubs	Age/Dam No. 4/	Weight	Total length	Shoulder height	Girth	Foreleg	Neck	Width	Length
BK	8/15/79	T		B161	B162	NA	M	C/B106	16	--	--	--	--	--	--	--
BK	8/15/79	T	Rp	B146	B145	NA	F	C/106	10	--	--	--	--	--	--	--
BK	8/15/79	T	Rp	B106	B132	106	-	--	--	--	--	--	--	--	--	--
PL	8/17/79	T		B163	B164	NA	M	6+ 5/	74	--	--	--	--	--	--	--
HF	8/18/79	T	Rp	B159	B160	159	-	--	--	--	--	--	--	--	--	--
TB	8/21/79	T	Rp	B106	B132	106	-	--	--	--	--	--	--	--	--	--
HF	8/26/79	T	Rp	B159	B160	159	-	--	--	--	--	--	--	--	--	--
HF	8/26/79	T		M1		--	F	13	88	144	83	93	31	55	15.6	25.1
TB	5/19/80	T		B166	B165	165	M	6	82	160	87	97	34	60	17.8	28.3
CC	5/20/80	H	Rc	B101	B133	10A	F/3	8	--	138	86	--	--	57	--	--
TB	5/20/80	H	Rc	NA	B168	109	M	13	98	--	--	--	--	--	--	--
PK	5/21/80	H	Rc	B111	B303	141	M	6	69	172	85	93	33	54	16.5	26.4
HF	5/21/80	H		B173	B174	140	F	3	--	109	66	63	26	33	11.4	21.0
PK	5/21/80	H		B301	B302	142	F/3	8	50	145	81	82	28	43	15.6	25.1
HF	5/21/80	H	Rc	B147	B138	143	F	19	41	144	77	71	--	41	14.3	24.5
PL	5/21/80	H		B306	B305	144	F/1Y	6	--	124	--	72	--	42	--	--
CK	5/22/80	H	Rc	B134	B140	145	M	6	--	--	--	--	--	--	--	--
RL	5/22/80	H		M2		--	F/1Y	10+	--	--	--	--	--	--	--	--
WF	5/22/80	H		B171	B172	146	M	8	98	154	83	93	32	55	17.8	28.2
TL	5/22/80	H		B199	B200	148	F	2	--	124	67	61	--	37	14.0	24.8
MM	5/22/80	H		B183	B184	147	F	16	--	148	79	71	--	43	14.9	25.7
SB	5/23/80	H		B185	B186	149	F	10	44	149	80	74	--	46	15.2	24.8
TB	7/23/80	T		B177	B178	NA	M	2	--	143	74	--	--	51	--	--
WK	8/6/80	T		B169	B170	169	F	13	78	158	82	93	23	54	15.6	26.7

1/ Refer to Fig. 5 for geographic location.
2 S = foot snare, T = barrel-type trap, and H = helicopter.
3 Blank = initial capture, Rp = repeat capture in same year, and Rc = recapture in a subsequent year.
4/ M = capture related mortality.
5/ Age = number of cemental annuli, C = "cub", under 1 year of age, and Dam No. = No. ear tag of dam..

APPENDIX B

Sex composition (males/females) for 3 age categories of black bears (<5, 5-9, and >9 years) killed during the spring hunting seasons (January through June) in 5 different areas (geographical management subunits 4, 5, 6, 7, 8) of Game Management Unit 6 grouped under 2 circumstantial intensities of harvest for 2 periods, 1974-77 and 1978-80. Prince William Sound.[1]

	1974-77				1978-80			
Treatment (subunit)	<5	5-9	>9	Total	<5	5-9	>9	Total
Heavily hunted								
4	8/6	26/7	4/3	38/15	13/7	11/7	5/2	29/16
6	12/5	15/8	3/1	30/14	11/2	6/2	0/3	17/7
7	9/5	8/9	2/4	19/18	8/5	11/0	3/0	22/5
4, 6, and 7	29/16	49/24	9/8	87/48	32/14	28/9	8/5	68/28
% Males	64	67	53	65	74	76	62	71
% Bears	33	54	12		48	39	14	
Lightly hunted								
5	29/7	21/13	10/7	60/27	11/6	10/2	3/1	24/9
8	7/3	16/7	6/2	29/12	3/0	7/3	5/0	15/3
5 and 8	36/10	37/20	16/9	89/39	14/6	17/5	8/1	39/12
% Males	78	65	64	70	70	77	89	71
% Bears	36	45	20		39	43	18	

[1] These geographical management subunits were identified for research purposes only and are not to be confused with officially designated Subunits within GMU 6.

APPENDIX C

Den Site Characteristics of Prince William Sound Black Bears.
by Sterling Miller, Charles Schwartz and Dennis McAllister

Black bear dens utilized in winter 1980/81 by bears radio-collared in connection with population identity studies in Prince William Sound (Modafferi, in prep.) were located, marked and measured in 1981. Den sites for these same bears in 1981/82 were approximately located by fixed-wing aircraft in January 1982. The purpose of this work was to provide baseline data on characteristics of Prince William Sound black bear den sites. Such data are valuable in light of increased developmental activities anticipated in the area, especially logging. These observations also provide comparison data to that being collected on the Kenai Peninsula (Schwartz and Franzmann 1981) and along the upper Susitna River (Miller and McAllister 1982).

All radio-collared bears were in dens when bears were located by fixed-wing aircraft on 15 April 1981. However, 2 bears, both males, had left their dens by 23 April 1981 when dens were marked; only approximate locations and elevations are available for the dens of these 2 males (as well as for all 1981/82 dens). Nine bears, all females, were still in dens on 23 April 1981 and these dens were marked with radio-collars, flagging and/or evident topographic features. 1981/82 dens will be similarly marked if time and available funds permit.

Marked dens were visited in summer 1981 and their characteristics were noted and dens were measured. The measurements followed those outlined by Schwartz and Franzmann (1981) with the addition of a subjective characterization of relative quality on a scale from 1 (poor) to 5 (excellent). These data are presented in Table 1 and Fig. 1.

Of the 9 measured dens, 5 were in mature hemlock (Tsuga spp.) forests, a forest type likely to be heavily exploited by increased logging efforts. Hollow trees were used as dens by 3 bears denning in hemlock forests (Table 1). In 1981/82 all 10 dens tentatively located were in hemlock forests or hemlock associations (Table 2).

Interestingly, 8 of the 9 dens examined in 1981 were in natural cavities (3 in trees, 3 in rock caves, and 2 under large boulders on talus slopes (Table 1); only 1 den was excavated by a radio-collared black bear.

In 7 cases a determination or reasonable guess could be made on whether an examined den had been previously used by a black bear. In 4 of these previous use by black bears was evident or suspected (Table 1).

Frequency of reuse of the same den by the same individual appeared low, although individual bears tended to den in the same general vicinity in successive years. None of the dens visited in 1981 was reused by radio-collared bears in 1982, although one bear (144) denned close enough to its previous den (0.25 miles) to be within the range of radio-tracking and plotting errors (Table 2). Den site locations prior to 1980/81 are available for only a few individuals (Modafferi, pers. commun.). Female 101 apparently used the same den in 1977/78 when she entered the den with a single cub as she did in 1980/81 when she entered with 3 cubs; she probably used the same den in 1979/80 but denned elsewhere in 1980/81, and apparently, in 1976/77. No den location was recorded for this bear in 1978/79. Two bears with radio-tracking histories (106 and 143) used different dens, 1-6 miles distant, in earlier years when den sites were approximately located (1977/78 and 1979/80 for 106 and 1977/78 for 143). The mean distance between dens for 10 individuals in 1980/81 and 1981/82 was 0.9 miles (0.25-1.88) (Table 2).

The time bears spent in 1980/81 dens could not be determined as the last flight in 1980 was on 29 September at which time all bears were still out. Emergence from dens seemed concentrated in the first 2 weeks of May for females and the last two weeks of April for the 2 males (Table 3).

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Table 1. Characteristics of Black Bear Dens in Prince William Sound, 1980-81.

Den No.	Bear No.	Age @ exit	Elevation ft.	Slope (degree)	Aspect (True N)	Vegetation	% canopy tree cover	Entrance Ht. (cm)	Entrance Width (cm)	Chamber Ln. (cm)	Chamber Width (cm)	Chamber Ht. (cm)	Total length (cm)	Prev. Used?	"Quality" **	Location & type
NATURAL CAVITIES																
Female w/offspring (at exit) w/3 yearlings																
1	101	9	375	10	352	Alpine tundra	0	38	47	216	160	96	800	Yes*	3	Blackstone Bay Rock talus
Females w/o offspring																
2	106	19	450	14	27	Hemlock	30	65	55	71	80	90	94	No?	4	Blackstone Bay Hollow tree
3	143	7	500	45	327	Hemlock	60	46	26	88	71	74	198	No?	2	Cochrane Bay Hollow tree
5	144	7	600	40	123	Hemlock	30	37	48	67	62	-	89	-?-	4	Cochrane Bay Hollow tree
6	169	14	300	26	330	Hemlock	20	55	104	175	126	67	308	Yes	3	Cochrane Bay Rock cave
7	148	3	400	50	187	Alder/Salmonberry	0	34	71	73	134	65	122	-?-	3	Culrose Passage Rock cave
8	147	17	900	55	122	Hemlock	80	178	42	128	114	118	980	Yes	3	Culrose Passage Rock talus
10	149	11	1250	60	187	Alpine tundra	0	43	59	86	86	53	268	Yes?	3	Cochrane Bay Rock cave
Males																
11	165	7	250 approx	-	-	Spruce	slight	-	-	-	-	-	-	-	-	Cochrane Bay (den not marked as bear out by 23 April)
12	146	9	350 approx	-	-	Alder(?)	0	-	-	-	-	-	-	-	-	Kings Bay (den not marked as bear out by 23 April)
DUG CAVITIES																
Females w/o offspring																
9	142	12	1300	52	185	Alder	0	36	52	70	129	92	80	No	3	Cochrane Bay

* Same bear used the den in 77/78 (w/1 ylg.), and probably in 79/80; not in same den in 76/77, unknown den location in 78/79.
** Subjective characteristics of quality, 1=poor and 5=excellent.

Table 2. Characteristics of black bear dens in Prince William Sound, 1981/82. (Based on locations from fixed wing aircraft on 4 Jan. 1982).

BEAR ID	Distance from 80/81 den (Table 1) (Miles)	Approximate Elevation (ft.)	Aspect	Slope	Habitat
101	0.81	450	NW	Steep	Hemlock-alder-rock
106	0.94	10	Flat	Flat	Alder-hemlock
143	0.53	80	NW	Moderate	Hemlock
144	0.25	750	SE	Steep	Hemlock-alder
169	1.88	400	NW	Steep	Hemlock-alder-rock
148	0.44	400	SW	Moderate	Hemlock-alder
147	1.19	650	S	Moderate	Hemlock
142	1.75	500	SE	Steep	Hemlock-alder
149	0.81	850	N	Steep	Hemlock
146	0.60	300	SE	Moderate	Hemlock
165	Not located in 1982.				
Mean	0.92	439			
S.D.	0.54	269			
Range	0.25-1.88	10-850			

Table 3. Den entrance and emergence dates of radio-collared Black Bears in Prince William Sound, winter of 1980/81.

Bear ID	Sex	Age @ exit	1980 Entrance *	1981 Emergence *
101	F	9	29 Sept.- ?	29 April - 14 May
106	F	19	29 Sept.- ?	29 April - 14 May
143	F	7	29 Sept.- ?	27 April - 29 April
144	F	7	29 Sept.- ?	29 April - 14 May
169	F	14	29 Sept.- ?	14 May - 22 May
148	F	3	29 Sept.- ?	29 April - 14 May
147	F	17	29 Sept.- ?	29 April - 14 May
149	F	11	29 Sept.- ?	29 April - 14 May
142	F	12	29 Sept.- ?	23 April - ?
165	M	7	29 Sept.- ?	15 April - 23 April
146	M	9	29 Sept.- ?	15 April - 23 April

* Last flight in fall was on 29 September when all bears were out of dens.

** Range represents last observation in den & first observation outside den.

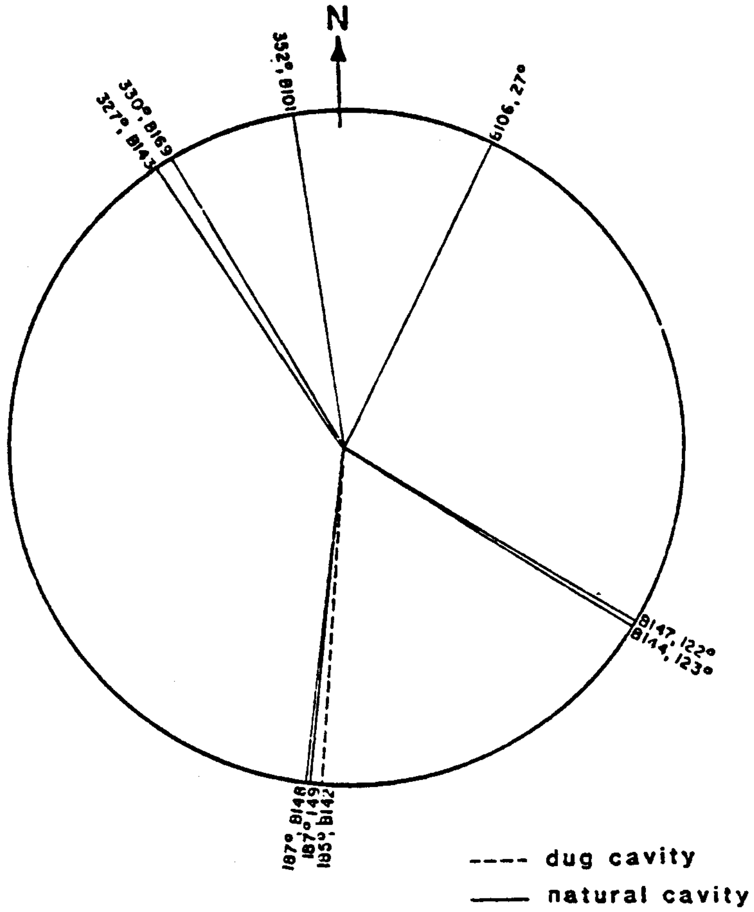

Fig. 1. Aspect for 9 black bear dens in northwestern Prince William Sound, Alaska, 1980-81.