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# ASPECTS OF THE ECOLOGY
# AND HUNTER HARVEST OF THE BLACK BEAR
# IN PRINCE WILLIAM SOUND

A

THESIS

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By
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ASPECTS OF THE ECOLOGY

AND HUNTER HARVEST OF THE BLACK BEAR

IN PRINCE WILLIAM SOUND

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ABSTRACT

Black bears in the Prince William Sound region were generally opportunistic in their selection of food items. Some of the principle foods were Gramineae in early spring; *Equisetum* spp., *Carex* spp., Polypodiaceae, and *Rubus spectabilis* in spring and summer; *Faurla cristagalli* and *Oncorhynchus gorbuscha* in late summer; and *Vaccinium* berries in the fall. The abundance of black bears in lightly hunted regions appeared to correlate with the abundance and variety of food items.

Black bear hunting has markedly increased in this region during the last decade. The length of time an area has been heavily hunted was found to be inversely correlated with the mean age of bears removed and the apparent abundance of bears remaining. The success of unguided hunters has declined markedly since 1966, greater numbers of hunters are going on guided hunts, and relatively more bears are being killed at greater distances from Valdez. Net population recruitment has not kept pace with bear removal in heavily hunted areas. However, bear hunting has been effective only in certain areas and at specific times. There appears to be a black bear density level below which further hunting with the techniques employed is unproductive.

Additional restrictions on unguided hunters are not justified. Game regulations should be enforced to curtail illegal guiding. Bear hunting in the immediate vicinity of Valdez has not been compatible with aesthetic enjoyment benefits to recreationists. Considering the importance of wildlife to the nonhunter, the area adjacent to the city should be closed to all hunting.

## PREFACE

This study was intended to be a pragmatic, management-oriented research effort into the relationship between hunting pressure and population responses of black bears in the Prince William Sound region of Alaska. Black bear hunting in this region has become popular within the last decade, and certain coastal regions which had previously been rarely hunted were subjected to relatively intense hunting pressure. Robert A. Rausch of the Alaska Department of Fish and Game suggested this project, presumably to acquire knowledge which would assure proper black bear management. The research objectives were to develop an understanding of black bear ecology, to monitor hunting pressure, and to assess the effect of hunting pressure on the black bear population.

The study draws heavily on data obtained in 1966 and 1967 by Carl Grauvogel, a previous graduate student at the University of Alaska. I collected data during 1968 and 1969. Comparisons are based, therefore, on four consecutive years of field work. This investigation was financed by funds from Federal Aid in Wildlife Restoration, Alaska Project No. W-17-1, work plan M-10, through the Alaska Cooperative Wildlife Research Unit.

I am especially indebted to the following people for their aid in bringing this thesis, and my education, to their present stage of development: to Dr. Frederick C. Dean for promoting my entrance into graduate school, Dr. Bonita J. Neiland for forming my basic precepts of plant and animal ecology, Dr. David R. Klein for shaping my basic precepts into an understanding of wildlife management, and to these three individuals, my committee advisors, for critically reviewing the thesis; to Dr. Robert L. Rausch of the Arctic Health Research Center at College, Alaska for patiently helping me solve the recurring technical problems associated with aging bears by counts of tooth cementum annuli; to Dr. David R. Murray for the hours involved in checking and correcting my identifications of the floral reference collection; to Alaska Department of Fish and Game personnel, especially Loyal Johnson for the use of a boat in 1968 and for providing specimen material, Ronald Mills for providing transportation in 1969, and Robert A. Rausch for support in initiating this study; to Bjørnulf Kristiansen for aid in collecting data in 1969; and to my wife, Per[illegible]-Ann, for sharing my interest in wildlife and typing initial and final drafts of this thesis.

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# STUDY AREA

## Location

The study area is located on the southcentral Alaskan coast in the Prince William Sound region (Fig. 1). It includes most of those areas hunted by Valdez-based black bear hunters and extends from Port Gravina to Eaglek Bay (Eaglek Bay is immediately west of Unakwik Inlet). The coastline between Port Gravina and Eaglek Bay is approximately 467 miles (751 km).

## Physiography

The physiography of the study area is primarily determined by its location at the intersection of the Chugach Mountain Range and the Pacific Ocean. Coastal slopes rise abruptly from sea level to mountain peaks ranging between 2,300 and 5,600 feet (700 to 1,700 m). Many of the peaks retain snowcaps throughout the summer, and low altitude glaciers are common. The coastline is irregular, forming many large inlets each of which contains several smaller bays. Alluvium accumulates where freshwater glacial streams empty into the bays and forms tidal marshes of up to several acres in size. Caps (1940) and Moffit (1954) give detailed descriptions of the geology of the region.

## Climate

The climate of the region is maritime but strongly influenced by nearby snowcaps and glaciers. Average annual precipitation is 62 inches (158 cm) and includes a mean annual 244 inches (620 cm) of

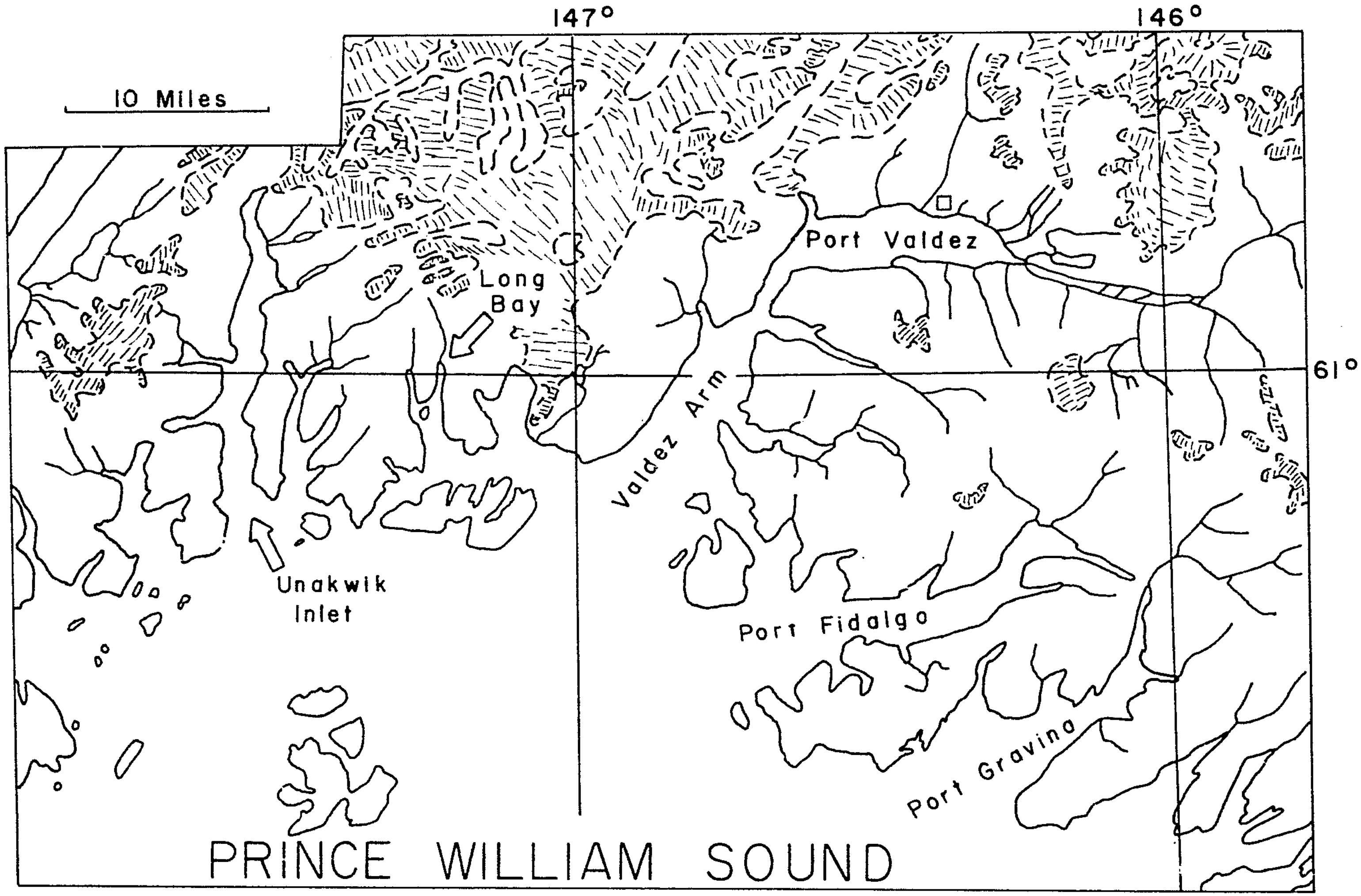


Figure 1. Map of the study area. From U.S. Army Map Service, Anchorage quadrangle. The area covered by glaciers is indicated by hatched lines.

sleet and snow (U.S. Weather Bureau climatological data for Valdez). Two-thirds of the summer days are overcast or rainy, and steady rain for two days is not uncommon (personal records). The maritime influence and cold air drainage from glaciers and snowcaps cause relatively cool summers. Winters are relatively warm since the surrounding mountains provide barriers to cold continental air masses. The maritime influence results in diminished snow accumulations and early snow melt at lower elevations. Local weather varies greatly within the study area, depending primarily upon the nearness of snowcaps and glaciers, the altitude, and the slope exposure.

Vegetation

Coastal slopes are grossly characterized by horizontal vegetational belts which differ in major species composition and dominant life forms. These upland communities, in turn, differ from vegetation on tidal marshes and stream margins. Vegetation within the study area is subdivided and described on the basis of these gross differences in conspicuous species. Plant species thought to be of importance to bears are included.

Fucus sp. frequently carpets estuarine basins exposed by low tides. Vegetation composed mainly of Elymus arenarius[1] and Carex spp. forms discontinuous bands on sandy beaches just above the high tide line, and these bands commonly expand into large acreages on tidal marshes. Other plant species common on tidal marshes and sandy beaches are

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[1]Nomenclature of plants follows Hultén (1968). Nomenclature of Ursidae follows Rausch (1963). The names of other mammals follow Hall and Kelson (1959).

Honckenya peploides, Calamagrostis deschampsioides, and Poa eminens.

Tidal marsh vegetation on alluvium is abruptly replaced by deciduous trees and associated understory further inland. Salix sitchensis, alone or mixed with Alnus crispa, forms a canopy for Epilobium latifolium, Equisetum arvense, and mosses. Additional plants found in openings between trees include Alnus and Salix saplings, Epilobium adenocaulon, Angelica lucida, Lupinus nootkatensis, and Gramineae (Arctogrostis latifolia and Calamagrostis deschampsioides).

Moist, semi-shaded sites support a variety of plants. Commonly found species are: Polypodiaceae (including Athyrium filix-femina ssp. cyclosorum and Blechnum spicant), Gramineae, Veratrum viride, Equisetum variegatum, Valeriana sitchensis, Streptopus amplexifolius, Geranium erianthum, and Lysitchitum americanum.

Coniferous forest covers most of the coastal slopes. Picea sitchensis is common at lower elevations and is usually mixed with Tsuga spp. T. heterophylla is restricted to low elevations and is relatively uncommon. T. Mertensiana composes most of the conifer cover and extends from low elevations to timberline in some places. Timberline along the coast generally ranges between 1,000 and 2,000 feet (ca. 300 to 600 m). A shrub understory composed mainly of Vaccinium ovalifolium, V. alaskensis, and Menziesia ferruginea is typical under conifers. Under the shrubs are found mosses and such herbaceous species as Rubus pedatus and Coptis trifolia.

Bogs have formed in depressions and on gently sloping ground. A survey of a bog showed the most common plants to be Fauria crista-galli, Sphagnum spp., Dicranium spp., Vaccinium uliginosum, and Empetrum nigrum. Other prominent species are Phyllodoce aleutica, Cornus spp., Drosera rotundifolia, and Trichophorum caespitosus. On rolling terrain, ridges, and terraced mountain slopes, the alternation of well-drained ground, covered by shrubs and conifers, with level-to-gently sloping open bogs is characteristic.

The conifer cover is frequently broken where snowslides and rockslides have occurred. Alnus crispa covers most of these disturbed areas; other common plants include Rubus spectabilis, Polypodiaceae, Echinopanax horridum, Sambucus racemosa, and Equisetum arvense.

Alnus crispa generally forms a belt above the conifers. On steep, north-facing slopes, however, Tsuga Mertensiana may extend up to timberline, and on well-drained, south-facing slopes Alnus may extend almost to sea level. Species commonly associated with Alnus are: Rubus spectabilis, Polypodiaceae (including Athyrium filix-femina ssp. cyclosorum), Echinopanax horridum, Equisetum arvense, and Veratrum viride. Well-drained sites between trees may have patches of Calamagrostis canadensis, and C. canadensis sometimes forms a continuous band just above timberline. Rubus spectabilis forms thickets on portions of some slopes, and Polypodiaceae (identified as Cystopteris fragilis in one instance) form dense patches in some subalpine situations.

Subalpine vegetation on peaks and ridges includes such species as Empetrum nigrum, Luetkea pectinata, Gramineae, Campanula lasiocarpa, Lycopodium sabinaefolium, Carex spp., mosses, and lichens (Cladonia spp. and Usnea sp.). The vegetation is similar to that of open bogs in moist situations with Fauria crista-galli, Vaccinium uliginosum, and Trichophorum caespitosus being prominent. I was seldom in the alpine zone and am unable to describe it.

Fauna

Among the terrestrial mammals, those most commonly seen or leaving sign at low elevations are bears (*Ursus arctos* and *Ursus americanus*) and river otters (*Lutra canadensis*). Brown-grizzly bears are found in the lower half of the study area (i.e., in the Lowe River Valley, Jack Bay, Port Fidalgo and Port Gravina). Manville and Young's circular (1965) describes other mammals found in the region. A wide variety of birds are seen in the study area. The Alaska Ornithological Society's checklist for the Anchorage area lists 152 species. Spawning salmon (including *Oncorhynchus gorbuscha* and *O. keta*) are commonly found in freshwater streams during the summer. Various invertebrates such as sea cucumbers (Cucumariidae), sea stars (Asteridae), and mussels (Mytilidae) are exposed in places by the falling tide.

## METHODS

Black bear population dynamics were correlated with hunting pressure by time-relative and space-relative comparisons. Time-relative comparisons were made by comparing hunting pressure and black bear population indices in one area over a period of successive years. Space-relative comparisons were made by comparing black bear population indices in areas having different intensities of hunting pressure during a single period of time. Efforts were made to ascertain that hunting pressure was the most influential variable on the black bear population for both time-relative and space-relative comparisons.

### Hunting Pressure

A hunter check station for unguided hunters and interviews with local guides provided data on hunting pressure for 1968 and 1969. Using similar methods, Grauvogel (1967) reported hunting pressure for 1966 and 1967. A history of the hunter-black bear interaction was accumulated by interviewing local residents, guides, and hunters.

There appeared to be no practical method of monitoring hunting pressure in the immediate vicinity of Valdez. The number of road-based hunters was diluted by many tourists. In addition, campground interviews revealed that a large proportion of tourists, hikers, campers, and fishermen were armed and motivated to shoot a bear should they get a chance. Such hunting pressure cannot readily be measured in terms of percent hunter success or number of hunting days per kill. Nevertheless, hunting pressure adjacent to the road system of Valdez appeared to be relatively heavy and constant.

Float-equipped aircraft were not used by Valdez-based hunters during 1968 and 1969. Grauvogel (1967) noted the limited use of aircraft in 1966 in a strictly charter capacity and not as a hunting vehicle.

Black bear hunters in Valdez primarily used boats for transportation. Civilian hunters generally used their own boats while military personnel most frequently used boats supplied by the army recreation camp at Valdez. Civilians and military personnel in varying numbers chartered a boat and operator. Although there were relatively few licensed guides operating out of Valdez, hunters utilizing a charter boat service were, in effect, on a guided hunt. To comply with Alaska game regulations, hunters chartering a boat for transportation should not hunt from that boat unless they are accompanied by a licensed guide.[2] This technicality is either unknown to most charter boat operators in Valdez or is disregarded. The terms "guide" and "guided" in this paper will refer to both licensed guides and charter boat operators.

The Valdez small boat harbor is compact, and the small boat traffic was relatively light. The probability of detecting unguided hunters while launching their boats, leaving, and returning from a hunt was high. During the hunting season a continuous surveillance of the boat harbor was made to facilitate contacting hunters. The following information was obtained from each hunting party: number of

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[2]See definition of guiding: Alaska Dept. of Fish and Game, Game and Guiding Regulatory Announcement No. 10, p. 81.

hunters, length and location of hunt, number and sex of bears killed, and other pertinent observations. Similar information on guided hunts was obtained by periodically interviewing local charter boat operators. Black bear skulls were collected from hunters when possible for subsequent aging studies.

Because of academic obligations in 1968, it was not possible to arrive on the study area until after spring hunting had started. Information about early season hunting was gathered from four sources. (i) The Valdez Army Recreation Camp personnel cooperated by supplying information on hunter success. (ii) Military personnel, hunting later in the season, were questioned about knowledge of successful early season hunters. (iii) Local residents supplied some information about early season kills. (iv) Early season hunters were contacted after the hunting season, and they supplied information concerning their hunts and the success of other groups that were hunting during the same period. Similar values for the numbers of successful hunters and the numbers of bears killed were obtained from three of the four different sources of information.

The study area can be divided into areas with different hunting intensities. Military boats prior to 1969 were restricted to coastal areas within 30 miles (48 km) of Valdez. Because of the danger in taking small boats out of protected bay waters and the commuting time required to reach remote areas, most unguided civilian hunters also hunted within 30 miles of Valdez. Guides took their clients to more distant, less heavily hunted areas. Port Fidalgo has been hunted by these guides in past years, but in 1967 and 1968 they were shifting to the previously rarely hunted areas of Long Bay and Unakwik Inlet. Part of the Valdez Army Recreation Camp burned in the late fall of 1968. As a result the conditions of the spring hunt in 1969 were somewhat altered. Military hunters obtained boats from interior bases such as Eielson Air Force Base and Ft. Wainwright. Previous restrictions had apparently been lifted, and military hunters ranged further, hunting in Port Fidalgo, Port Gravina, and Long Bay. These different area-specific hunting intensities provide a basis for correlations of hunting pressure with black bear population indices.

## Population Dynamics

Hypothetically, hunting pressure may cause some combination of the following changes in a bear population:

1) Reduced numbers due to removal, emigration, or both.
2) Relatively constant numbers but compensatory immigration, production of young, or both.
3) An altered sex structure due to hunter selection, differential vulnerability of the sexes, or both.
4) An altered age structure due to hunter selection, differential vulnerability of various age groups, proportional removal of the more abundant older age classes, increased production of young, or some combination of these factors.
5) Behavioral changes affecting the vulnerability of bears.

Ideally, changes in numbers, sex and age ratios, breeding biology, movements, and behavior should be assessed. In practice, I found it difficult to measure parameters of a black bear population.

No known method appears to be entirely suitable for assessing black bear abundance. A total census is impossible, and mark and recapture methods for estimating abundance are not practical. An aerial survey was attempted in the early spring of 1968. Although 235 miles (378 km) of coastline were overflown and three observers were present, only four bears were seen. Aerial surveys for black bears in this region are not very promising, even for trend indices. In support of this conclusion, only 108 observations of black bears in the study area were recorded during four years of aerial surveys of salmon spawning streams (Ralph Pirtle, unpublished data). Relatively poor success with aerial surveys has been reported for brown-grizzly bears in McKinley National Park (Dean, 1957) and on the Alaska peninsula (Erickson and Siniff, 1963). Disadvantages of abundance assessments based on track differentiation have been reported by Klein (1959). In addition, most of the substrate in the study area does not readily record tracks.

Approximations of absolute abundance used in this study are based on the number of bears killed and the number known remaining in relatively small bay areas. Resulting values are probably minimal. Hunting pressure appeared to be the primary variable effecting black bear numbers during the period of the study.

Indices of abundance are meaningful in time and space-relative comparisons. Changes in hunter success over a period of years and differences in hunter success in different areas during a single hunting season are used as indices of abundance. Another abundance index is the difference in the number and location of annual sightings of black bears by Valdez residents, guides, and hunters. The degree of correlation among the indices and the magnitude of change of each index are assumed to indicate the confidence which can be placed on the inferred relative abundance.

Information on breeding biology was limited to noting the incidence of sows with cubs and the litter size from my own observations pooled with those of hunters. Sex structure of the bear population was obtained from hunter reports. When skulls were available, sex was determined by skull morphology and dimensions (Marks and Erickson, 1966), skull width (Rausch, 1961), thickness and width of the lower canine (Sauer, 1966), and transverse diameter of the upper canine (Rausch, 1961). Age determination was based on counts of tooth cementum annuli.

Tooth Studies

Black bear skulls obtained from hunters were cleaned by boiling and were air-dried until further use. Subsequently, the skulls were measured, and the teeth were removed by chipping the bone from one side of the tooth. Of the molars, only the first molar (upper or lower) was used; incisors and premolars were often used without noting the exact tooth. Upper and lower canines were distinguished. Since some of the air-dried teeth had split, all teeth were coated with epoxy cement and were placed on glass microscope slides which had been abraded to facilitate adhesion. A median sagittal section was cut using an Ingran thin-section saw. Subsequent grinding, decalcifying, staining, and mounting followed the method described by Rausch (1969). Tooth sections were approximately 50 microns thick. A dissecting microscope, a compound microscope, and a microprojector were used for studying tooth structure. Dr. Robert L. Rausch (Arctic Health Research Center, College, Alaska) counted cementum annuli independently to serve as a check. Where discrepancies in age determination of one year occurred, I used my judgement as to the correct age. Discrepancies in age determination of greater than one year were indicated by age brackets, and the median value was used for calculations.

The cementum was thickest at the apex of the root on all teeth, especially on the posterior margin of the *in situ* root. The cementum became gradually narrower further from the root apex. Hematoxylin-stained cementum consisted of light-staining bands of variable width (hereafter referred to as summer bands) and uniformly narrow, dark-staining lines (hereafter referred to as winter bands).

*Canines*. Starting at the outer dentine layer approximately halfway between the root apex and the dentino-enamel junction, the first cementum band encountered in canines was a thin summer band corresponding to the second summer of life (Rausch, 1969). The second winter band terminated approximately one-third the root length above the root apex. Below this point the third summer band la, adjacent to the outer dentine layer. The third and fourth summer bands, and usually the fifth summer band, terminated above the root apex. The apical band was the fifth summer band in one canine, fifth winter band in six canines, sixth summer band in four canines, and sixth winter band in one canine. In correlation, the root canals of intact canine teeth from two bears aged three and four years old, respectively, were open and $>1$ mm in diameter. The root canals of two bears killed during their sixth spring (five years old) were open but measured $<1$ mm in diameter (one canal was tapered to a very small opening). The root canals of two bears killed during their seventh spring (six years old) were closed. Therefore, in this sample, the root canal usually closed during the fifth winter and sixth summer. These results are similar to those of Rausch (1961) on black bears and Rausch (1969) on brown bears.

Cementum annuli were usually counted beginning at the outer dentine layer just below the termination of the third summer band. Counting proceeded towards the posterior margin of the tooth. The summer bands often appeared almost equally wide through the 8th to 10th summer with subsequent bands appearing narrower in width. This characteristic was variable and was not found either higher on the tooth root or at the root apex. The summer bands in some teeth appeared to be continuously but irregularly reduced in width with increasing age.

A narrow, pale-staining secondary line was usually visible in the center of each summer band. Occasionally these secondary lines were prominent, resembling winter lines, and caused confusion in distinguishing the annuli (Rausch, 1969). The winter bands sometimes appeared to be doubled, especially if the tooth section was thick and not exactly median.

The first bears killed in the spring, presumably just after leaving hibernation, had one-fifth to one-third of a summer band already formed. The mid-summer secondary line was deposited as early as the second week of June. It was difficult to differentiate between dark-staining tooth margins and terminal winter bands under low magnification (30X). Using a compound microscope, two bears killed during the first week of September were found to have terminal summer bands. Some investigators have found terminal winter bands in fall-killed bears (Mundy and Fuller, 1964; Stoneberg and Jonkel, 1966), although Rausch (1969) did not find terminal winter bands in his material.

Primary dentine layers were seldom distinct on the root surface. Their points of termination were marked by an annulus on tooth sections (Rausch, 1969), but the laminations were indistinctly delineated. Secondary dentine annuli were separated by narrow, dark-staining lines which correspond to winter bands in the cementum (Rausch 1969). Usually the third narrow dentine line was not distinct, the fourth was noticably dark-staining, and the fifth line was stained as dark as subsequent lines. There were no dark dentine lines in canines of two bears aged three and four, respectively. There was one dark band in bears aged four (one bear) and five (two bears). Three bears six years of age had two dark dentine lines. Assuming, therefore, that the first dark dentine line corresponded to the fifth winter, the ages of 20 of 21 bears could be determined within one year (± 1 year) by counts of dark-staining dentine lines. There was an age discrepancy of two years between dentine and cementum annuli counts in one bear aged 20 years by cementum annuli counts. Dentine annuli could not be counted in canines from three additional bears over 13 years of age because the sections did not pass through the center of the root canal. Dentine annuli were closely approximated on old bears, and magnifications of 100X and 430X were useful.

In comparison to counting cementum annuli, aging black bears by counting dentine annuli frequently required closer study. In addition, dentine annuli in sagittal sections which did not exactly bisect the canal were often difficult to resolve. Counts of dentine annuli may be useful as a check on cementum annuli counts.

Incisors, Premolars, and Molars. A first winter cementum band was usually distinct in premolars (Stoneberg and Jonkel, 1966). It was also seen in incisors and molars. Frequently a thin first summer band was distinct. Occasionally the first winter band was indistinct, and the relatively broad second summer band was the innermost cementum layer. In molar sections (M1), between the roots and under the crown, the first summer band often approached the width of subsequent summer bands. The first winter band terminated above the root apex. The winter band encircling the root apex varied from the second to the fourth.

Dentine annuli in incisors and premolars were often distinct. The first dark dentine line was formed in the second to fourth winter in all cases where it was distinct. The correlation of age determinations from secondary dentine and cementum annuli would possibly have been exact had I accounted for differences in time of root closure among premolars and incisors. The root canal was small, however, and it was difficult to get median sagittal sections. On old bears the dentine depositions were so closely adjacent to one another that they could not always be resolved. Consequently, age determination by counts of dentine annuli in incisors and premolars was not as reliable as dentine annuli counts in canines.

Molars frequently showed an apparent doubling of cementum winter bands and prominent secondary lines. Age determination by cementum annuli counts was not always possible. My sagittal sections of molars were usually oblique, and this may have been the source of the difficulty. Similarly, dentine annuli in molars were not distinct.

Tooth Comparisons for Age Determination. Generally, incisors and premolars were preferable for aging purposes. Summer bands at the apex in median sagittal sections were uniformly wide and easy to count, even from 20 year old bears. In contrast, the outer cementum annuli were often difficult to distinguish in canine teeth from old bears. Although secondary lines were usually visible in canines, occasionally they were prominent and easily confused with winter bands. Secondary lines were not as prominent in premolars and incisors. Canines had a tendency to fragment while air-drying and during sawing and grinding operations; premolars and incisors remained intact. Some hunters preferred to keep the bear skull and prominent teeth but were willing to relinquish a premolar tooth. Finally, premolars and incisors were relatively easy to extract.

## Food Habits

A total of 326 black bear scats were gathered from the Prince William Sound study area. Four of these scats were collected in 1968; the remainder were collected in 1969. All of the scats were collected from bays in which there was no sign of brown-grizzly bears. Collections were restricted to scats less than a year old. The resistance of a scat to weathering varies with its composition. As examples, scats containing primarily *Carex* were durable, but scats containing primarily berries often remained intact for only a few weeks. Weathering of scats can be relatively rapid (Tisch, 1961). They were soaked, leached, and pounded formless by the frequent rains. Some were infested with Diptera larva and scattered by birds. I found relatively few scats produced the previous year, and these were often soaked by the spring thaw and penetrated by new vegetation. Scats gathered in some areas probably reflected the total diet of bears until the time of collection. Fall collections more closely reflected the current diet of the bear because of rapid weathering of scats containing berries and deposition of scats near salmon streams where they could be periodically collected. A reference flora was collected from the study area during 1968 and 1969 in preparation for the scat analysis.

The scat analysis procedure was similar to the method described by Hatler (1967). Most of the scats had been preserved in a 5% formalin solution; those scats that had been dried required soaking for several days prior to analysis. The scats were placed in a large container and dissociated with a strong jet of water. The material was poured on a sieve (30 meshes to the inch) except for approximately 2 ml of sediment which was collected from the bottom of the container. The remaining material was transferred from the sieve to a white enameled tray where it was floated in water. A one-to-two ml sample was obtained, segregated, and identified. Almost all of the segregation and identification was performed with the use of a variable power (7X to 30X) dissecting microscope. Volume estimates for each scat inclusion were made by visual estimation, the categories used being trace (<1%), 1-5%, 6-25%, 26-50%, 51-75%, and 76-100%. Gravimetric checks were made periodically on visual estimates to assure accuracy. The specific gravity of water-soaked scats had been previously determined and was found to be approximately 1.0. After analyzing the scat sample, the sediment sample for that scat was scanned under 7X magnification for bone fragments. Then a light was placed over the remainder of the scat in the tray, and the material was grossly examined for scat inclusions not contained in the samples.

## FOOD HABITS

### Scat Analysis

The items found in scats are included in group designations and listed in Table 1 and Table 2. Most of the Gramineae were not identifiable to genus. Scats found near *Alnus*-covered slopes probably contained *Calamagrostis canadensis*. Gramineae blades similar in appearance to *Arctagrostis latifolia* were seen in some scats gathered around inland lakes and streams. All the Polypodiaceae in the scats collected resembled *Athyrium filix-femina* ssp. *cyclosorum* and *Cystopteris fragilis* or *Dryopteris dilatata*. The latter two species were not distinguishable because frond fragments bore no sori. *Equisetum arvense* was much more common than *E. variegatum* in scats. *Vaccinium ovalifolium* and *V. alaskensis* could not usually be separated in the scat material; however, *V. ovalifolium* was more common in the study area. *V. caespitosum* was identified in only a few scats; *V. uliginosum* was not seen in scats, although it was common in the study area. *Vaccinium* foliage was more common than berries before July 15; afterwards, berries of *Vaccinium* were more common than leaves. *Fauria crista-galli* was often difficult to identify if the semi-digested petioles were the main component present. Bears were observed to place their heads close to the ground when cropping *Fauria*, biting the central portion of the petiole and letting the blade fall to the ground. Field evidence indicated that the selective cropping of *Fauria* petioles was the usual event. Similarly, the succulent fruiting stalks and leaf veins of *Lysichitum*

Table 1. Items found in black bear scats collected in the Prince William Sound region during spring, 1969.

| Items found in Scats | Collected May 17 through July 13 (78 scats) | | |
|---|---|---|---|
| | % scats at trace only[a] | % scats> tr.[b] | Mean % Vol. for scats> tr.[c] |
| Gramineae | 0 | 6 | 51-75 |
| Polypodiaceae | 10 | 28 | 26-50 |
| *Equisetum* spp. | 1 | 24 | 51-75 |
| *Rubus spectabilis* | 4 | 27 | 26-50 |
| *Oncorhynchus* spp. | 0 | 1 | 26-50 |
| *Vaccinium* spp. | 6 | 6 | 6-25 |
| *Fauria crista-galli* | 0 | 13 | 26-50 |
| *Streptopus amplexifolius* | 3 | 0 | |
| *Carex* spp. | 8 | 55 | 51-75 |
| *Sambucus racemosa* | 0 | 0 | |
| conifer needles | 41 | 0 | |
| unidentified moss | 14 | 0 | |
| sand and stones | 4 | 0 | |
| unidentified vegetation | 15 | 15 | 6-25 |
| unidentified roots | 3 | 0 | |
| bear hair | 0 | 0 | |
| Insecta - adults | 10 | 3 | 1-5 |
| Arthropoda larva | 12 | 0 | |
| *Lysichitum americanum* | 0 | 0 | |
| *Lupinus* spp. | 0 | 0 | |
| *Luetkea pectinata* | 0 | 0 | |
| *Alnus crispa* | 4 | 0 | |
| *Angelica lucida* | 1 | 0 | |
| wood fragments | 3 | 0 | |
| woody twigs | 4 | 1 | 1-5 |
| Pelecypoda shell | 1 | 0 | |
| egg shell fragments | 0 | 0 | |
| fungi mycelia | 0 | 0 | |
| *Rubus stellatus* | 0 | 0 | |
| *Oxycoccus microcarpus* | 0 | 0 | |
| *Coptis trifolia* | 1 | 0 | |
| *Prenanthes alata* | 0 | 0 | |

[a]Number of scats, expressed as a percentage, which contained the item in trace quantity (less than 1%).

[b]Number of scats, expressed as a percentage, which contained the item in greater than trace quantity.

[c]The mean volume, expressed as a percentage, of those items occurring in greater than trace quantity.

Table 2. Items found in black bear scats collected in the Prince William Sound region during fall, 1969.

| Items found in Scats | Collected July 20 through Aug. 26 (248 scats) | | |
|---|---|---|---|
| | % scats at trace only[a] | % scats> tr.[b] | Mean % Vol. for scats>tr.[c] |
| Gramineae | 0.8 | 2 | 51–75 |
| Polypodiaceae | 2 | 15 | 26–50 |
| *Equisetum* spp. | 2 | 12 | 26–50 |
| *Rubus spectabilis* | 11 | 32 | 26–50 |
| *Oncorhynchus* spp. | 3 | 36 | 26–50 |
| *Vaccinium* spp. | 8 | 79 | 26–50 |
| *Fauria crista-galli* | 8 | 36 | 26–50 |
| *Streptopus amplexifolius* | 15 | 17 | 6–25 |
| *Carex* spp. | 16 | 21 | 6–25 |
| *Sambucus racemosa* | 4 | 1 | 6–25 |
| conifer needles | 37 | 2 | 1–5 |
| unidentified moss | 11 | 1 | 1–5 |
| sand and stones | 7 | 0.8 | 1–5 |
| unidentified vegetation | 11 | 2 | 6–25 |
| unidentified roots | 0.8 | 0 | |
| bear hair | 6 | 0 | |
| Insecta - adults | 1 | 0 | |
| Arthropoda larva | 33 | 2 | 1–5 |
| *Lysichitum americanum* | 0.4 | 0.4 | 26–50 |
| *Lupinus* spp. | 0 | 0.4 | 1–5 |
| *Luetkea pectinata* | 2 | 0 | |
| *Alnus crispa* | 0.4 | 0 | |
| *Angelica lucida* | 0.8 | 0 | |
| wood fragments | 2 | 0 | |
| woody twigs | 3 | 0 | |
| Pelecypoda shell | 0 | 0 | |
| egg shell fragments | 0.4 | 0 | |
| fungi mycelia | 2 | 0 | |
| *Rubus stellatus* | 0.4 | 0 | |
| *Oxycoccus microcarpus* | 0.4 | 0 | |
| *Coptis trifolia* | 0 | 0 | |
| *Prenanthes alata* | 0.4 | 0 | |

[a]Number of scats, expressed as a percentage, which contained the item in trace quantity (less than 1%).

[b]Number of scats, expressed as a percentage, which contained the item in greater than trace quantity.

[c]The mean volume, expressed as a percentage, of those items occurring in greater than trace quantity.

americanum were selected preferentially to the leafy portions. The bulk of the material included in the category of "unidentified vegetation" was fibrous material and may have been the digested remains of Lysichitum americanum and Fauria crista-galli. Only the drupes and woody fruiting stalks of Sambucus racemosa were observed. Rubus spectabilis foliage was present in spring scats; berries predominated over foliage in fall scats. Two scats gathered June 12 and June 13 contained over 75% by volume of R. spectabilis blossoms. There appeared to be no preferential representation of Streptopus amplexifolius berries over foliage in the scats. Conifer needles were mainly those of Picea sitchensis and Tsuga Mertensiana. They were present in a high percentage of scats in trace volumes. Probably some of these occurrences were due to needles picked up along with the scat as well as needles enveloped by the recently-formed scat. Similarly, the presence of moss, stones, Luetkea pectinata, Alnus crispa, coniferous woody twigs, wood fragments, Oxycoccus microcarpus, Rubus stellatus, and Coptis trifolia probably represents collecting artifacts and not food items in many instances. Insecta adults were mainly identified as wasps. Ants were expected but not observed. Scavenger beetles and skin beetles were identified in a few scats but were probably invaders of the formed scat. Maggots composed most of the Arthropoda larva and were common invaders of scats containing berries. Fungi formed on some of the scats while I was trying to dry them under field conditions. Spawning Oncorhynchus gorbuscha were seasonally common in streams in the study area, and smaller numbers of O. keta were also present. Identifiable fish remains in scats were not prominent. Bone and fin ray fragments were small and relatively rare, even in sediment samples. The most reliable and voluminous indication of a fish diet was the presence of "organic mud" - brownish aggregates (sometimes gray-white or green) that disintegrated into minute suspended particles under light pressure. Because much of this "organic mud" was removed during preparation of the scat for examination, fish volumes were generally underestimated.

Scat collections were divided into spring (July 15 and before) and fall (after July 15) categories and listed in Table 1 and Table 2, respectively. Hatler's (1967) study of the food habits of the interior black bears demonstrated that relatively few food items constituted the bulk of the bears' diet. By comparison, many food items are seen to contribute to the diet of these coastal black bears.

The pooled results are only indicative of the overall pattern of black bear feeding habits. Spring and fall categories are classified by more specific dates and locations of collections in Table 3. Only those food items which occurred in more than 5% of the scats and at greater than trace quantity in either spring or fall categories are listed. Scat collections from May 17 to June 1 on south-facing Alnus-covered mountain slopes revealed that the principle food items were Gramineae, Equisetum, and Polypodiaceae, listed in order of decreasing importance (Table 3). In the low-altitude canyons, scats collected from June 2 to June 13 indicated the principle foods to be Equisetum and Rubus spectabilis. Oncorhynchus carcasses from the previous year's spawning activity still lay on the streambanks and probably accounted for the fish remains in this collection group.

Table 3. Temporal and spatial comparisons of scat composition.

| Date: | May 17 - June 1 | | June 2 - June 13 | |
|---|---|---|---|---|
| Location: | South-facing, Alnus-covered mountain slope, 60-600 m elevation. | | Canyon slopes, Alnus cover broken by disturbed areas, 0-60 m. | |
| Number of Scats: | 6 | | 9 | |
| Food Items[a] | % scats[b] | $\bar{X}$ % Vol.[c] | % scats[b] | $\bar{X}$ % Vol.[c] |
| Gramineae | 67 | 76-100 | 0 | |
| *Carex* spp. | 0 | | 0 | |
| Polypodiaceae | 33 | 6-25 | 22 | 1-5 |
| *Equisetum* spp. | 33 | 76-100 | 89 | 51-75 |
| *Rubus spectabilis* | 17 | 6-25 | 78 | 26-50 |
| *Fauria crista-galli* | 0 | | 0 | |
| *Vaccinium* spp. | 0 | | 0 | |
| *Oncorhynchus* spp. | 0 | | 11 | 26-50 |
| *Streptopus amplexifolius* | 0 | | 0 | |
| unidentified vegetation | 17 | 1-5 | 22 | 6-25 |

[a]Food items occurring in greater than trace quantity and in more than 5% of the spring or fall collection of scats.

[b]Number of scats, expressed as a percentage, which contained the item in greater than trace quantity.

[c]The mean volume, expressed as a percentage, of those items occurring in greater than trace quantity.

Table 3. (Continued)

| Date: | June 27 - June 29 | | June 27 - July 6 | |
|---|---|---|---|---|
| Location: | Low altitude island with a shoreline supporting *Carex*; conifer-dominated ridges and open bogs were found inland. | | Margin of large *Carex*-dominated tidal marsh. | |
| Number of Scats: | 24 | | 13 | |
| Food Items[a] | % scats[b] | $\bar{X}$ % Vol.[c] | % scats[b] | $\bar{X}$ % Vol.[c] |
| Gramineae | 0 | | 0 | |
| *Carex* spp. | 92 | 76-100 | 69 | 51-75 |
| Polypodiaceae | 13 | 26-50 | 54 | 51-75 |
| *Equisetum* spp. | 4 | 76-100 | 15 | 26-50 |
| *Rubus spectabilis* | 8 | 26-50 | 15 | 6-25 |
| *Fauria crista-galli* | 21 | 6-25 | 0 | |
| *Vaccinium* spp. | 8 | 26-50 | 0 | |
| *Oncorhynchus* spp. | 0 | | 0 | |
| *Streptopus amplexifolius* | 0 | | 0 | |
| unidentified vegetation | 8 | 1-5 | 15 | 6-25 |

[a]Food items occurring in greater than trace quantity and in more than 5% of the spring or fall collection of scats.

[b]Number of scats, expressed as a percentage, which contained the item in greater than trace quantity.

[c]The mean volume, expressed as a percentage, of those items occurring in greater than trace quantity.

Table 3. (Continued)

| Date: | June 26 - July 2 | | July 10 - July 13 | |
|---|---|---|---|---|
| Location: | Canyon slopes, *Alnus* cover broken by disturbed areas, 0-60 m. | | Inland locations, not close to tidal marshes. | |
| Number of Scats: | 13 | | 13 | |
| Food Items[a] | % scats[b] | $\bar{X}$ % Vol.[c] | % scats[b] | $\bar{X}$ % Vol.[c] |
| Gramineae | 0 | | 8 | 1-5 |
| *Carex* spp. | 54 | 51-75 | 39 | 26-50 |
| Polypodiaceae | 15 | 26-50 | 46 | 51-75 |
| *Equisetum* spp. | 15 | 26-50 | 31 | 51-75 |
| *Rubus spectabilis* | 54 | 26-50 | 15 | 51-75 |
| *Fauria crista-galli* | 8 | 76-100 | 31 | 51-75 |
| *Vaccinium* spp. | 8 | 6-25 | 15 | 6-25 |
| *Oncorhynchus* spp. | 0 | | 0 | |
| *Streptopus amplexifolius* | 0 | | 0 | |
| unidentified vegetation | 23 | 51-75 | 15 | 6-25 |

[a]Food items occurring in greater than trace quantity and in more than 5% of the spring or fall collection of scats.

[b]Number of scats, expressed as a percentage, which contained the item in greater than trace quantity.

[c]The mean volume, expressed as a percentage, of those items occurring in greater than trace quantity.

Table 3. (Continued)

| Date: | August 9 - August 24 | | July 20 - August 10 | |
|---|---|---|---|---|
| Location: | Varied habitats; spawning salmon not available. | | Varied habitats; spawning salmon available. | |
| Number of Scats: | 13 | | 27 | |
| Food Items[a] | % scats[b] | $\bar{X}$ % Vol.[c] | % scats[b] | $\bar{X}$ % Vol.[c] |
| Gramineae | 8 | 26-50 | 0 | |
| *Carex* spp. | 23 | 1-5 | 22 | 6-25 |
| Polypodiaceae | 8 | 76-100 | 26 | 51-75 |
| *Equisetum* spp. | 38 | 51-75 | 15 | 26-50 |
| *Rubus spectabilis* | 38 | 26-50 | 30 | 26-50 |
| *Fauria crista-galli* | 31 | 51-75 | 52 | 26-50 |
| *Vaccinium* spp. | 69 | 26-50 | 67 | 26-50 |
| *Oncorhynchus* spp. | 0 | | 30 | 26-50 |
| *Streptopus amplexifolius* | 15 | 6-25 | 0 | |
| unidentified vegetation | 0 | | 0 | |

[a]Food items occurring in greater than trace quantity and in more than 5% of the spring or fall collection of scats.

[b]Number of scats, expressed as a percentage, which contained the item in greater than trace quantity.

[c]The mean volume, expressed as a percentage, of those items occurring in greater than trace quantity.

Table 3. (Continued)

| Date: | August 11 - August 19 | | August 20 - August 26 | |
|---|---|---|---|---|
| Location: | Varied habitats; spawning salmon available. | | Varied habitats; spawning salmon available. | |
| Number of Scats: | 117 | | 69 | |
| Food Items[a] | % scats[b] | $\bar{X}$ % Vol.[c] | % scats[b] | $\bar{X}$ % Vol.[c] |
| Gramineae | 0 | | 0 | |
| *Carex* spp. | 18 | 26-50 | 20 | 6-25 |
| Polypodiaceae | 11 | 26-50 | 15 | 26-50 |
| *Equisetum* spp. | 12 | 6-25 | 10 | 26-50 |
| *Rubus spectabilis* | 35 | 26-50 | 28 | 26-50 |
| *Fauria crista-galli* | 37 | 26-50 | 30 | 26-50 |
| *Vaccinium* spp. | 78 | 26-50 | 87 | 51-75 |
| *Oncorhynchus* spp. | 39 | 26-50 | 33 | 26-50 |
| *Streptopus amplexifolius* | 16 | 6-25 | 19 | 6-25 |
| unidentified vegetation | 0 | | 0 | |

[a]Food items occurring in greater than trace quantity and in more than 5% of the spring or fall collection of scats.

[b]Number of scats, expressed as a percentage, which contained the item in greater than trace quantity.

[c]The mean volume, expressed as a percentage, of those items occurring in greater than trace quantity.

Collections from June 27 to June 29 from an island probably represented the diet of bears from early spring until the collection date. Carex was the principle food item; but Polypodiaceae, Equisetum, and Rubus spectabilis were important dietary components. Fauria crista-galli and the foliage of Vaccinium were being utilized during the collection period. Scat collections from June 27 to July 6 near tidal marshes indicated utilization of Carex, Polypodiaceae, Equisetum, and Rubus spectabilis, listed in decreasing order of importance. Field observations confirmed that Carex was still being utilized by some bears.

Scat collections from June 26 to July 2 were made along the lower portion of freshwater streams, from tidal marsh margins to perhaps one mile upstream. Scats tended to be predominately composed of either Carex or a variety of other species (especially Rubus spectabilis). Scat collections made from July 10 to July 13 were at inland locations distant from tidal marshes. Principle foods in these areas were Polypodiaceae, Equisetum, and Fauria crista-galli.

Vaccinium (mainly berries), Rubus spectabilis (mainly berries), Fauria crista-galli and Oncorhynchus spp. were the major dietary components during the month of August. A comparison of scat collections through August demonstrates the increasing importance of Vaccinium in the bears' diets. A comparison of scats from habitats similar to each other but for the presence of spawning salmon indicates that fish are a preferred food item when available. As previously noted, the listed volume of fish in the diet is probably a large underestimation. The listed value for the frequency of occurrence of fish in the diet is less likely to be in error.

Bear diets varied with the season and with the habitat. It follows that the accuracy of this food habits study is influenced by the time and space representativeness of the total scat collection. Collecting efforts were unscheduled, however, and this study is intended to indicate only the range and chronology of food selections.

Field Observations and Discussion

Bears may emerge from "dormancy" (Matson, 1967) in April. The only available food during this time, however, would be *Fucus* sp. and various invertebrates exposed by low tides (Clark, 1957) and salmon carcasses along stream margins from the previous year's spawning activities. Most bears killed early in the spring were fat, but there were two instances in which the bears were reported to be emaciated (one of these bears also had "millions of lice"). It seems possible that delayed availability of early spring forage may act in concert with physiological debility to naturally limit bear populations. However, Knudson's (1961) publication reporting continued weight losses of bears until August supports Matson's (1967) reservations about the nutritive value of spring and summer forage for bears and supports Hatler's (1967) hypothesis that black bears are somewhat dependant upon berries.

In early May of 1969 snow had receded from the lower 500 feet (ca. 150 m) of south-facing coastal slopes but still lay on north-facing slopes almost to tidal margins. The only green plants observed on south-facing slopes at this time were *Veratrum viride* (30 cm tall), Polypodiaceae in the fiddlehead stage (15 cm high), and Gramineae (presumed to be *Calamagrostis canadensis*, 15 cm high). *Elymus* arenarius on a nearby tidal marsh was less than 10 cm high and of a sparse density. Hunters reported seeing bears mainly in clearings on coastal slopes and only infrequently on tidal marshes. Field observations supported scat analyses findings in that Gramineae were the main early spring food item. Bears could still be seen feeding on Gramineae during late spring in subalpine areas where Calamagrostis canadensis forms a band between timberline and true alpine areas. Gramineae has been frequently mentioned as a major dietary component during the spring (Chatelain, 1950; Clark, 1957; Knudson, 1961; Matson, 1967; Skinner, 1925; Tisch, 1961; Wright, 1910).

The importance of "cabbage" (Veratrum viride) in the early spring diet of bears is uncertain. A previous investigator (Grauvogel, 1967) reported that Veratrum viride was the most important early spring food item. Hunters frequently reported that bears were eating in "cabbage" patches, and one hunter reported seeing Veratrum leaves in stomach contents. I was unable to confirm the importance of Veratrum either through scat analyses or field observations. It appeared to be cropped uncommonly relative to its abundance. Veratrum has been reported to contain poisonous alkaloids which act on the heart rate and blood pressure and can be fatal to livestock, deer, elk, and chickens (Craighead, Craighead, and Davis, 1963). Conclusive evidence is lacking, but it appears that bears feed mainly on Gramineae which often grows in proximity to the prominent Veratrum plants.

Elymus arenarius on tidal marshes was approximately 30 cm high and of dense coverage by the third week of May in 1969. Gramineae and Carex spp. on shorelines and tidal marshes assumed importance in bear diets during this time. The peak use of tidal marsh vegetation occurred from the third week of May through the first week of June. Possibly the palatability of Carex, the main food item on tidal marshes, then declined relative to Polypodiaceae, Rubus spectabilis, and Equisetum which were found inland. However, bears were occasionally observed eating Carex spp. on tidal marshes in July and August. Bear carcasses left by hunters near tidal marshes were generally cannibalized within a few days.

Alnus and Rubus spectabilis leaves began opening in mid-May, and bears were no longer visible on Alnus-covered slopes within a week after the leaves started to appear. During the last two weeks of May, however, bears could be seen feeding in clearings and on colluvial slopes. The main food items were Gramineae, Polypodiaceae, and Rubus spectabilis. Other plants observed to be food items were Angelica lucida, Salix alaskensis, and Lysichitum americanum. Signs of cropping of Equisetum were not seen. Many of these plants were also reported to be food items in the studies of Chatelain (1950), Clark (1957), Hatler (1967), and Tisch (1961). Field observations, compared to scat analyses results, overemphasized the importance of conspicuous plants such as Angelica lucida and Lysichitum americanum and underemphasized the importance of such plants as Rubus spectabilis and Equisetum arvense.

Bears were widely dispersed during the month of June. Carex, Equisetum, Rubus spectabilis, and Polypodiaceae continued to be the main food items. There were many observations of rotten tree trunks torn apart and holes scooped out of open bogs. Although no evidence was found which would indicate what the bears were after, they were probably searching for insects (Chatelain, 1950; Knudson, 1961; Murie, 1954; Rust, 1946; Skinner, 1925; Tisch, 1961; Wright, 1910). Bark was chewed from roots and trunks of coniferous trees in some instances, either for the cambium or for the sap which exuded from the wounds (Glover, 1955; Levin, 1954; Lutz, 1951; Merrill, 1953; Murie, 1954; Zeedyk, 1957).

Spawning salmon were being caught by some bears during the first week of July. The timing of spawning seemed to vary within the study area. Generally, salmon weren't numerous enough to be easily caught until the second and third weeks of July. Bears were observed to catch salmon either by chasing and pouncing on them in shallow streams (the usual technique) or by swimming in schools of salmon and snapping at them as they attempted to escape (one bear's technique). At least some bears feed heavily on salmon (Shuman, 1950); one bear was observed to catch 10 salmon in a $2\frac{1}{2}$ hour interval. Lively swimming fish were selected in preference to dead and dying fish which littered the streambanks in the fall. Salmon were sometimes consumed on the streambank, but the usual practice was for them to be consumed in nearby cover. Rutted bear trails along spawning streams and heavily-used adjacent cover attested to the high bear density in these areas.

Even while bears were relatively plentiful around spawning areas, fresh bear sign could also be found dispersed on coastal slopes both close to and distant from spawning areas. Radiating trails from spawning areas disappeared within a mile, suggesting a limited commuting distance. Considering that most of the fall scat collection was gathered in the vicinity of salmon streams, it appears possible that salmon constituted a high volume in a relatively low percentage of diets of the total bear population. The number of bears feeding on spawning salmon appeared to decrease in late August; a similar observation was reported by Troyer and Hensel (1964). Although bear dispersal away from salmon spawning streams may have been a response to my frequent presence in the vicinity, I believe that bear dispersal was mainly due to the attraction of ripening *Vaccinium* berries on nearby slopes. Based on evidence from observations, my presence probably did not have a lasting affect on bear distribution.

*Fauria crista-galli* petioles became an important food item by the first week of July. The peak use of this plant was in mid-to-late July. *Fauria* blades started turning reddish-brown in some areas during mid-August, and signs of its use declined duri this period.

The importance of *Carex* spp. as a food item was partly due to their occurrence in widely diverse habitats. *Carex* was the most conspicuous plant on many tidal marshes and was an important spring food item. Freshly cropped *Carex* could be found until July in inland streamside situations. *Carex* was interspersed with *Fauria crista-galli* in some bogs, and the two plants were consumed together during July and August. Cropped *Carex* plants were also found below melting snowpacks high on north-facing slopes in late July where the *Carex* plants were still small and tender.

*Vaccinium ovalifolium* berries were half-ripe by the second week of July. A bear was observed during this period curling his tongue around a branch tip and eating foliage as well as green berries. Scats collected in late summer contained undigested Vaccinium berries along with leaves and twigs. This situation altered by mid-August. Two bears observed eating ripe Vaccinium berries during this period quickly picked the individual berries, rapidly moving from shrub to shrub. Scats collected in the fall often contained digested Vaccinium berries almost exclusively. Hatler (1967) reported that over 12,000 blueberries were found in the stomach of one bear. Bears could probably get more berries per unit time from V. ovalifolium than from related species. The berries of V. uliginosum were relatively small, and V. alaskensis was relatively uncommon. There was no apparent movement of bears into alpine areas during August as was found for interior black bears by Hatler (1967).

The berries of Rubus spectabilis became ripe during the latter part of July. These berries were relatively large but were frequently not abundant on plants. Their incidence in the bears' diet seemed to parallel their availability. On some slopes where Rubus spectabilis forms large, dense thickets, these berries were possibly more important than Vaccinium berries in the black bears' fall diet.

Field observations terminated by the first of September when the fall hunting season started.

It seems well demonstrated that a black bear's diet depends to a large extent upon the specific habitat and the relationship between vegetational development and season. Bears within a specific habitat eat whatever preferred food items are most available. However, food preferences, surpluses, and shortages cause individual bear movements and result in spatial shifts of bear populations on a local scale.

Examples of temporary bear concentrations to feed on Gramineae in the first snow-free areas, to feed on Carex spp. on tidal marshes, and to feed on spawning salmon have been noted. It seems useful to emphasize the difference between population shifts of individually-motivated bears and population shifts of herding animals. Bear distributions appeared almost continuous from low to high density areas, and only a proportion of the bears appeared to participate in local, temporary concentrations. Conversely, herding animals may have discrete patterns of distribution, and population shifts may involve all or most of the individuals. Almost no coastal habitats were incapable of supporting bears, and, therefore, few coastal habitats were entirely without bears. The lowest unhunted bear densities were seen (i) where dense coniferous forests were associated with a moss understory and (ii) on gently sloping hillsides where bogs were numerous and almost confluent in coverage. Food sources for bears in these situations were limited in variety and at least seasonally in abundance. In contrast, some areas had an abundance and variety of preferred food items for much of the year and supported a large bear population. An inland stream near Jonah Bay (a small bay off Unakwik Inlet) is an example. Bears could be found near this valley from spring through the fall at a density of approximately eight bears per square mile. Bear densities appeared highest in habitats where the following features were present: large tidal marshes supporting mainly Carex spp.; freshwater streams seasonally carrying large numbers of spawning salmon; and steep, forested coastal and canyon slopes with a Vaccinium understory and with many clearings supporting patches of Gramineae, Polypodiaceae and Rubus _spectabilis_. The best bear habitats were centered about the lower portions of freshwater streams.

In summary, bear density in unhunted areas ranged from high to low, apparently depending on the food resources of the habitat; on a more local scale, bear densities varied due to bear movements in relation to preferred food availability. Only food in relation to bear movements has been discussed. The interplay of all causal factors affecting bear distribution is unknown.

## POPULATION DYNAMICS

### Absolute Abundance

Assessments of black bear abundance are speculative. The fissured, precipitous, densely forested coastal slopes introduce unavoidable error into areal measurements, and difficulties in enumerating black bears are well known. Some knowledge of populations in two different bays in the study area will provide an approximate value for density.

Perhaps the most reliable estimates can be made on populations in the Jonah Bay area, a small bay off Unakwik Inlet (Fig. 1). Black bear movements into and within the area were restricted by estuarine water and snowcapped and alpine ridges. Alpine areas and glaciers are not considered bear habitat and are excluded from areal measurements. An area of 4.4 square miles would include the timbered slopes, creek margins, and tidal marshes of part of the Jonah Bay area. There have been 13 bears killed within this area since 1968, and I was able to distinguish an additional 23 bears. Density is calculated to have been eight bears per square mile (3.2 bears per sq km) of usable habitat (ecological density) which I speculate is a minimum estimate for that location.

Measurements from a map of the timbered slopes and drainages surrounding tidal marshes in Long Bay give a value of 2.3 square miles. Some of this area is especially folded, and the true area may be closer to 4 square miles. Since the fall of 1967, 33 black bears

(19 males, 1 female, 13 with sex unknown) have been shot on the tidal marshes. I could distinguish an additional 12 bears (mainly sows with cubs) near the tidal marshes and 5 more bears on a portion of the adjacent coastal slope. As a conservative estimate, 55 bears lived throughout the year on 4 square miles of habitat assessed as the best in the study area. Ecological density, based on usable habitat, is calculated to have been about 14 bears per square mile (5.4 bears per sq km). The extent of net population recruitment through movements and production of young since heavy hunting began is unknown but is probably not large.

Grauvogel (1967) made a spot census of black bears feeding on an open slope in early spring. His estimate for bear density in good habitat was 10 bears per square mile (3.8 bears per sq km).

These assessments of abundance were based on semi-isolated bear populations occupying good habitat. Probably the value of 10 bears per square mile is the best approximation for bear densities in unhunted bay areas. A large portion of the coastal region consists of timbered tracts containing less dense populations of bears. The value of 10 bears per square mile is in accord with Troyer and Hensel (1964) for Kodiak brown bear ecological densities but is considerably higher than other values reported for black bear densities in Yellowstone National Park (Bray, 1966), Virginia (Davenport, 1953), Michigan (Erickson, Nellor, and Petrides, 1964), Pennsylvania (Wakefield, 1969), and interior Alaska (Hatler, 1967). Differences in density are presumed to be due to the higher quality of portions of the coastal habitat.

In heavily-hunted areas near Valdez, density of black bears was much lower. Based on observations of recognizable bears correlated with distribution of bear sign during a survey, bear density in Mineral Creek canyon and the mountain overlooking Valdez was approximately 1.4 bears per square mile (Fig. 2). On the heavily hunted south-facing slope between Gold Creek and Mineral Creek, observations by hunters indicated a bear density of approximately 0.4 bears per square mile. These assessments of absolute abundance are crude, but they do reflect the magnitude of difference between bear densities in heavily and lightly hunted areas.

Relative Abundance

Black Bear Sightings - Time and Space Comparison. Black bears were commonly seen in the vicinity of old Valdez in the early and mid-1950's. In the late 1950's and early 1960's the local residents noted a decline in black bear sightings, and this decline seemed to correlate with increasing numbers of hunters. The continuity of observations was broken in 1964 because of the resettlement of residents from "old" to "new" Valdez following earthquake damage. However, most residents that were interviewed have seen less than two bears per year in the vicinity of Valdez since 1966.

Along the bays and estuaries within 30 miles of Valdez, fishermen and hunters reported that black bears were commonly seen until the interval 1965 to 1967. The decline in sightings during this period was substantial; for instance, one charter boat operator reported seeing 50 to 60 black bears per year in the early 1960's but only 0 to 2 black bears per year since 1966.

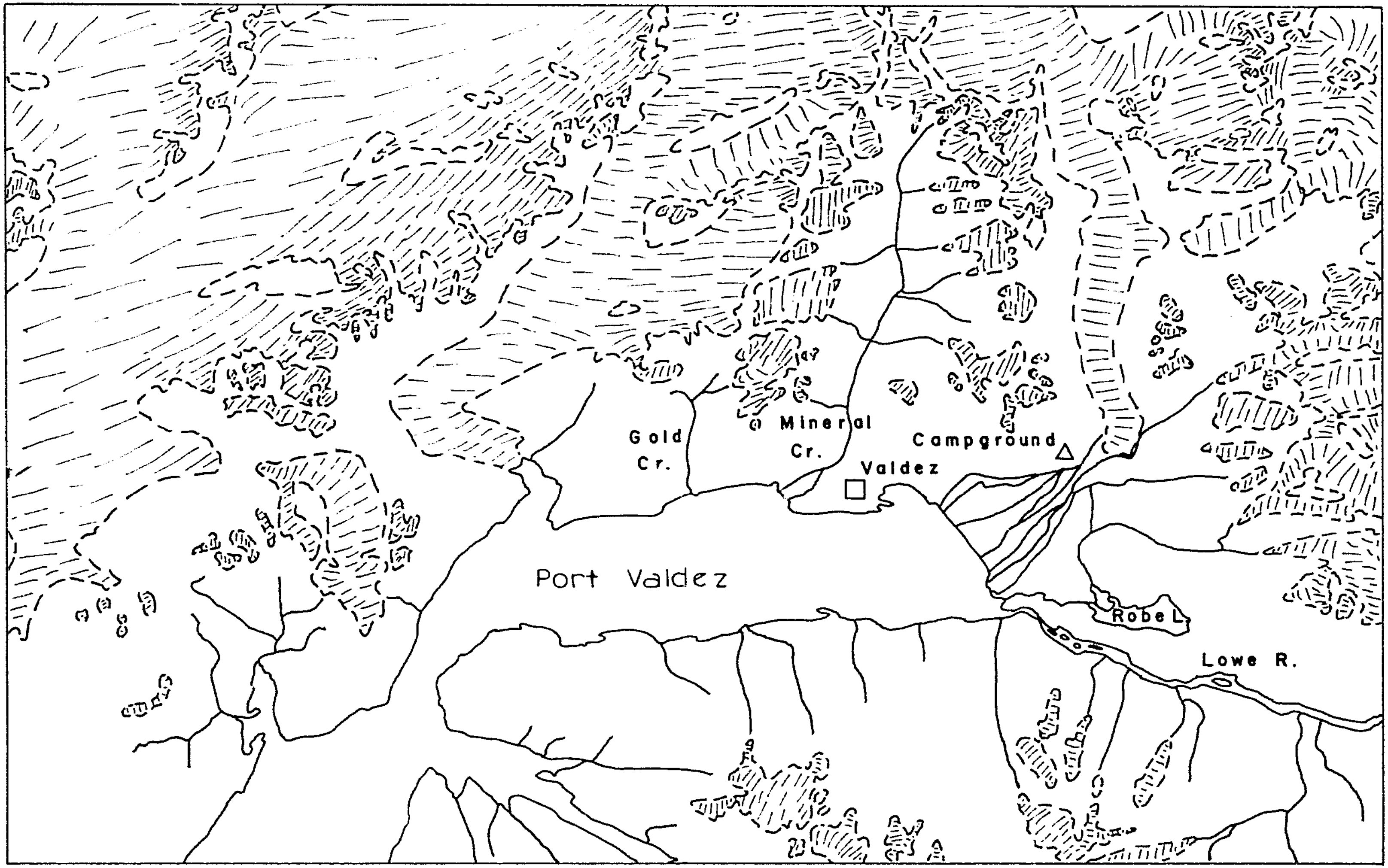


Figure 2. Map of Valdez vicinity. From U.S. Geological Survey Map, Valdez quadrangle. Center coordinates are approximately 146° 30' W and 61° 7' N. Scale is 1:250,000 (1 inch approximately equals 4 miles).

In Long Bay, which is more than 30 miles from Valdez, a charter boat operator's hunting clients killed 11 black bears in the fall of 1967 and 14 bears in the spring of 1968. Within a year's time 25 black bears were killed in a bay that has a shoreline of approximately 18 miles. Therefore, this relatively small bay had an abundant black bear population at least until 1967.

Most of the charter boat operators believed that bears were most abundant in such remote coastal areas as Unakwik Inlet during 1969.

In summary, an increase in black bear hunting pressure in the 1950's and 1960's apparently correlates with a decline in number of black bear sightings, first in the vicinity of Valdez and later at successively greater distances from Valdez.

Hunter Success - Time and Space Comparisons. Hunter success is mainly determined by the vulnerability of black bears to hunting. Assuming a year-to-year constancy of factors which affect vulnerability of black bears, annual hunting success is then an index of abundance of those black bears that are available to hunters. Hunter success is expressed as (i) percentage of unguided hunters which were successful and (ii) mean number of hunting days per kill in Figure 3.

Hunting pressure in the Port Valdez - Valdez Arm vicinity essentially started with the opening of the Valdez Army Recreation Camp in June, 1962 (Capt. Hugh Hagen, pers. comm.). Assessment of the cumulative bear harvest between 1962 and 1966 involves speculation. Hunting success for 1965 was recalled by hunters as being as high as it was in 1966. Therefore, I estimate that approximately 100 bears were removed in 1965 during the spring and fall hunts. There were fewer hunters in

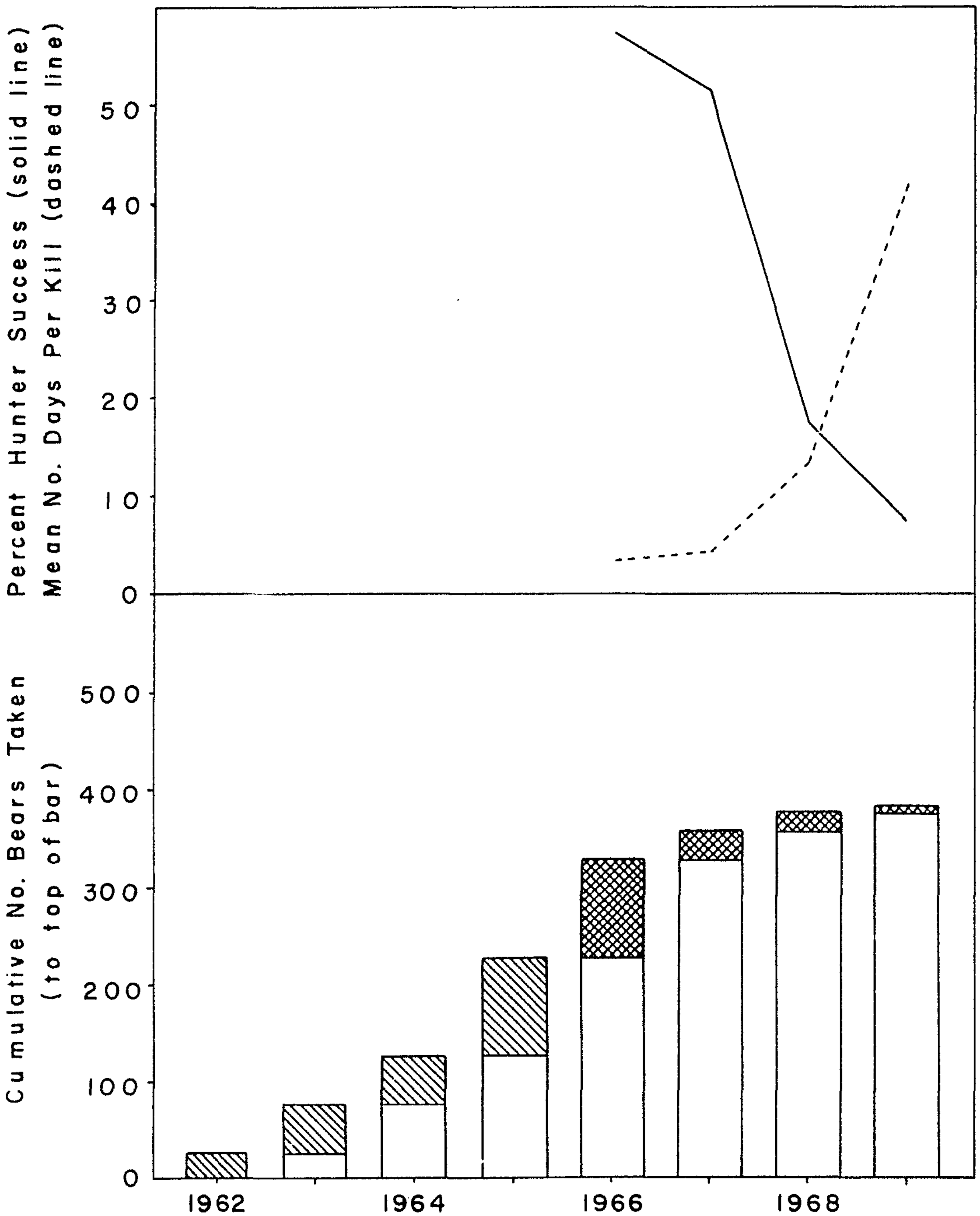


Figure 3. Graphs comparing annual and cumulative bear harvests with percent hunter success and mean number of hunting days per bear killed for the Port Valdez-Valdez Arm vicinity. The estimated annual bear harvests are indicated by diagonal hatching, and the known annual bear harvests are indicated by cross hatching.

1963 and 1964, but the hunter success was relatively high. An estimated kill of 50 bears per year for 1963 and 1964 is probably conservative. Since the army recreation camp opened late in 1962, the bear kill for 1962 was probably in the range of 10 to 50 bears. There was little hunting in the bay area before 1962. The accumulated bear kill for the years 1962 to 1965 (estimated) and 1966 to 1969 (increments known) is illustrated in Figure 3. The apparent decline in abundance of the bear population correlates with the cumulative bear harvest.

Space-relative comparisons of hunting pressure and black bear abundance are illustrated in Table 4. The areas compared are illustrated in Figure 4. The low bear harvest in Port Valdez and Valdez Arm in 1969 correlates with the low relative abundance of bears. Conversely, the high bear harvest in remote areas correlates with a relatively abundant population in those areas.

The spread of hunting pressure from Valdez in recent years is suggested by the distribution of annual bear harvests since 1966. As previously noted, guided hunters in 1969 were shifting their hunting pressure from Long Bay to the Unakwik Inlet vicinity, and unguided hunters were spreading into Port Gravina, Port Fidalgo, and Long Bay as hunting success continued to decline in Port Valdez, Valdez Arm, and adjacent bays.

Age Structure Correlated with Hunting Pressure

The ages of bear teeth submitted by Valdez-based hunters during the period 1966 through 1969 are pooled and presented in Table 4 according to the location where each bear was killed. Bear ages and kill locations in 1966 and 1967 are from Grauvogel (1967). The mean

Table 4. Correlation of hunting pressure, mean age of bears killed, and 1969 abundance indices for selected areas.

| | Port Valdez & Valdez Arm | Ports Fidalgo & Gravina | Long Bay | Unakwik Inlet Vicinity |
|---|---|---|---|---|
| Distance from Valdez (approx.): | 0-30 miles (0-48 km) | 40-70 miles (64-112 km) | 40 miles (64 km) | 50-80 miles (80-128 km) |
| First Year Heavily Hunted (approx.): | 1962 | 1965 | 1967 (fall) | 1969 |
| Number of Years Hunted (approx.):[a] | 4 | 2 | 0.5 | 0 |
| Distribution of Known Annual Bear Harvest,[b] | | | | |
| 1966: | ca. 103 | 10 | 0 | 0 |
| 1967: | 28 | 12 | 11 | 0 |
| 1968: | 19 | 5 | 14 | 10 |
| 1969: | 6 | 8 | 8 | 19 |
| 1969 Abundance Indices, | | | | |
| Spring Hunter Success, Percent of All Hunters:[c] | 7 (81) | 35 (20) | 25 (32) | 48 (29) |
| Mean Number of Days per Kill: | 42 | 16 | 5.8 | 5.5 |
| Mean Age of Bears Killed:[d] | 6.9 (48) | 7.8 (36) | 9.8 (8) | 12.2 (14) |
| Percent of Harvested Bears in Age Classes,[d] | | | | |
| 1-4 years: | 27 (13) | 13 (5) | 0 | 0 |
| 5-8 years: | 52 (25) | 57 (20) | 25 (2) | 36 (5) |
| 9-12 years: | 10 (5) | 10 (4) | 63 (5) | 28 (4) |
| 13+ years: | 10 (5) | 20 (7) | 12 (1) | 36 (5) |

[a]Approximate number of years heavily hunted preceding the sampling of harvest for bear ages.

[b]Data for 1966 and 1967 are from Grauvogel (1967).

[c]Values in parentheses refer to number of hunters in the sample.

[d]Numbers in parentheses refer to the number of bears in the sample. Samples for the years 1966 to 1969 were pooled. Data for 1966 and 1967 are from Grauvogel (1967).

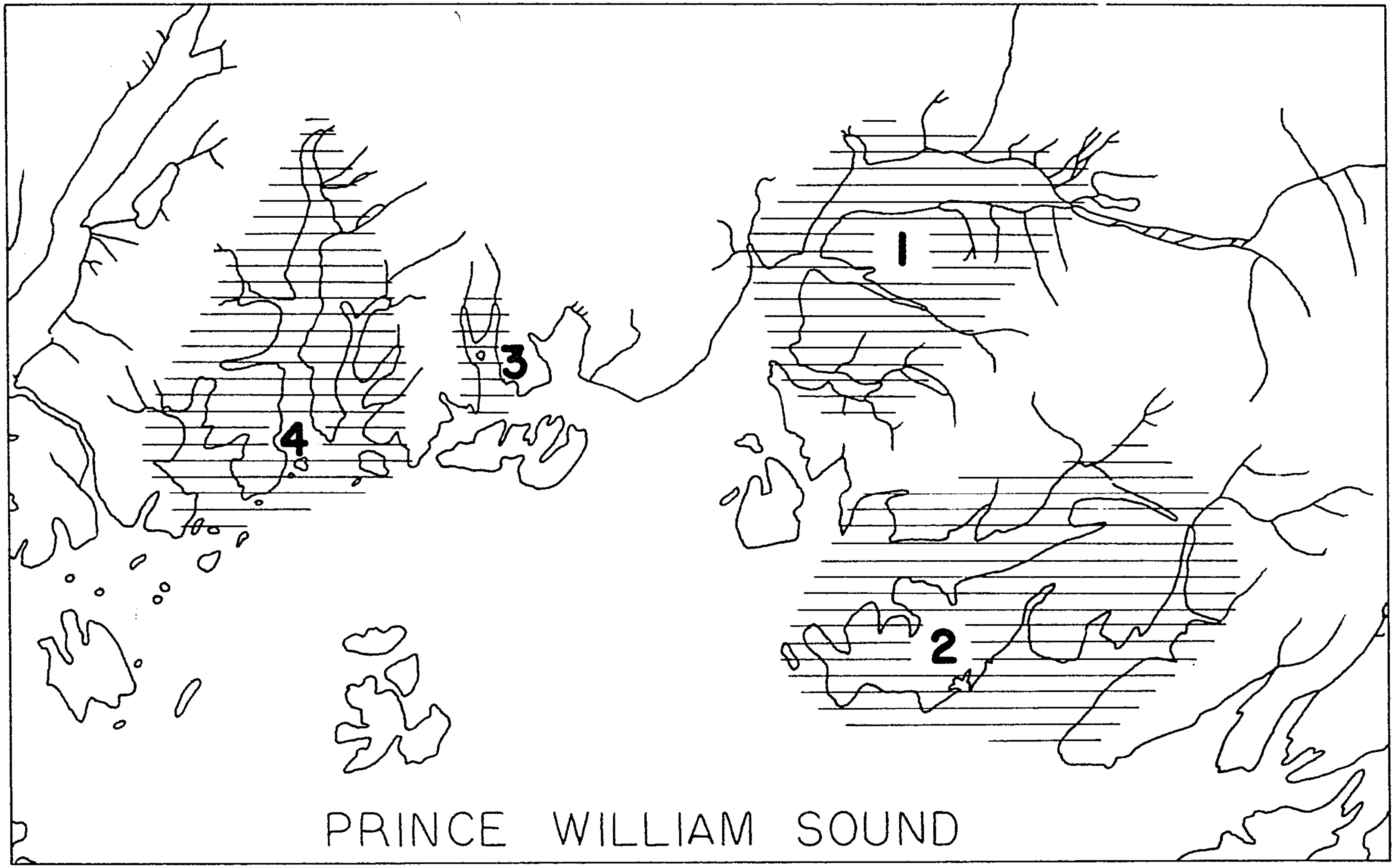


Figure 4. Map illustrating regions with different intensities of hunting pressure. Region 1= Port Valdez and Valdez Arm. Region 2 = Port Fidalgo and Port Gravina. Region 3 = Long Bay. Region 4 = Cedar Bay, Wells Bay, Unakwik Inlet containing Jonah and Siwash Bays, and Eaglek Bay. The area covered by this map is the same as in Figure 1.

age of bears killed in the Port Valdez-Valdez Arm region (6.9 years) is less than the mean age of bears killed in remote regions (12.2 years). Within a given area, the number of years of heavy hunting pressure is inversely correlated with the ages of bears removed and with the apparent abundance of bears remaining. The age class distribution of bears confirms that a higher proportion of older age groups came from areas with the shortest history of hunting pressure.

Sex Structure and Productivity

Reported sex ratios of hunter-killed black bears for the years 1966 through 1969 are listed in Table 5. The large composition of male bears in the harvests of 1968 and 1969 suggested inaccurate reporting by hunters. As a check against this possibility, sex was determined by skull and tooth measurements on a sample of the bears harvested in 1968 and 1969 (Table 6). Not only was the large male composition of the harvest verified, but two of three bears reported as females were apparently males.

Males may predominate in the harvest because of hunter selection, differential availability of bears to hunters, or both. The bases of hunter selection can be positive selection of the relatively larger males (Troyer and Hensel, 1964), negative selection of sows with cubs, or both. However, I doubt that hunter selection was important in determining sex ratios of bears killed in the study area during 1968 and 1969 for the following reasons:

1) Black bear sows with cubs were infrequently seen. In 1968 and 1969, my own observations pooled with those reported by hunters revealed that 242 single bears were seen compared to 16 sows with

Table 5. Reported sex ratios of hunter-killed bears from 1966 to 1969.[a]

| | 1966 | 1967 | 1968 | 1969 |
|---|---|---|---|---|
| Sex Ratio, Male/Female | | | | |
| Spring Hunt: | 29/11 | 22/21 | 28/5 | 28/5 |
| Fall Hunt: | 6/8 | | | 2/1 |

[a]Data for 1966 and 1967 are from Grauvogel (1967).

Table 6. Comparison of reported sex with sex derived from skull and tooth measurements from a sample of the 1968 and 1969 bear harvest.

| Spec. No. | Age | Reported Sex | Sex Derived from Skull Morphology[a] | (Skull Length + Width, mm)-Sex[a] | (Skull Width, mm)-Sex[c] | ($C_1$ Root Width + Depth, mm) Sex[b] | ($C^1$ Transverse Diameter, mm) Sex[c] |
|---|---|---|---|---|---|---|---|
| 1 | 19 | M | M | (532) M | (176) M | (31.8) M | (14.0) M |
| 2 | 5 | M | F | (417) M | (148) M | (28.6) M | (12.3) ? |
| 3[d] | 10 | M | | | | (31.4) M | (13.4) M |
| 5 | 19 | M | M | (465) M | (183) M | (33.7) M | (12.3) M |
| 9 | 6 | M | M? | (419) M | (151) M | (27.9) M | (11.6) M |
| 10 | 9 | M | F | (412) F | (151) ? | (27.7) M | (11.9) M |
| 11 | 9 | M | M | (469) M | (173) M | (31.9) M | (14.2) M |
| 12 | 9 | F | M | (457) M | (171) M | (32.0) M | (14.0) M |
| 13 | 20 | F | M | (469) M | (178) M | (31.6) M | (13.7) M |
| 14 | 21 | M | M | (462) M | (180) M | (30.9) M | (12.3) M |
| 15 | 4 | F | F | (347) F | (126) F | (22.2) F | (9.1) ? |
| 30[d] | 5 | M | F? | | (138) M | (26.7) ? | (11.1) ? |
| 31 | 6 | M | F? | (409) M | (144) M | (32.8) M | (13.4) M |
| 32 | 8 | M | M | (462) M | (164) M | (28.7) M | (12.1) M |
| 33 | 15 | M | M | (467) M | (178) M | (29.7) M | (12.9) M |
| 34 | 13 | M | [illegible] | (470) M | (172) M | (30.9) M | (11.7) M |
| 35 | 10 | M | M | (534) M | (184) M | (34.2) M | (12.5) M |
| 37 | 7 | M | M? | (426) M | (148) M | (28.9) M | (10.5) ? |
| 39[d] | 6 | M | M? | | | (32.4) M | (12.7) M |
| 40[d] | 10 | M | M? | | | (28.8) M | (12.1) M |
| 41 | 7 | M | M | (444) M | (163) M | (29.9) M | (12.3) M |
| 42 | 7 | M | M | (430) M | (159) M | (29.7) M | (11.7) M |
| 43 | 20 | M | M | (472) M | (179) M | (31.0) M | (13.1) M |

[a]Based on data from Marks and Erickson (1966).
[b]Based on data from Sauer (1966).
[c]Based on data from Rausch (1961).
[d]Bullet-damaged skull.

first-year cubs. Hunters usually didn't have the opportunity to exercise negative selection of family groups.

2) Hunter selection for size was discouraged by charter boat operators. They were paid, in effect, by numbers of bears killed per unit time and not by the trophy value of the bear.

3) It was difficult to judge the size of bears when they were distant or in even minimum cover.

4) In recent years the opportunities for a kill have been limited. Although the bag limit was at least two bears until the 1969 fall hunt, few hunters shot more than one bear.

Therefore, the sex ratio of the spring harvest was apparently determined by differential availability of the sexes. Within a given year, differential availability may reflect differences in group behavior, differences in numbers of each sex, or both. Differential behavior appears to have been a factor influencing the sex ratio of the harvest. First, sows with first-year cubs emerge from hibernation later than do male bears (Matson, 1967; Rust, 1946; Wright, 1910). Early in the season, before leaf development of deciduous vegetation, family groups feeding or moving on coastal slopes would have been visible. Although bears may be nocturnal in some areas (Erickson, 1965), almost all of the bears seen and shot in the study area (several hundred bears) were undisturbed but active in daylight when first detected. I saw bears, including sow-cub groups later in the season, engaged in undisturbed activity during all hours of the day. Family groups were not generally seen in early spring, and this probably indicates that they were not active. Second, after leaving the den site, sows seldom take first-year cubs far from heavy cover (Bray, 1966; Erickson, 1965). Sows have been observed near salmon spawning areas for periods of over one-half hour while cubs rested and played in nearby cover. Sows were noted to leave cubs in adjacent cover while grazing on tidal marsh vegetation on two occasions. I observed seven sow-cub groups (some groups were seen repeatedly), and all observations were in or near heavy cover. Finally, harvest data in other studies indicate that male bears are relatively more susceptable to hunting pressure (Free, 1968; Stickley, 1957). No explanation for male vulnerability was reported.

While differences in behavior of males and sows with first-year cubs may explain sex ratios in a single harvest, behavior within groups would be expected to remain relatively constant from year-to-year. Sex ratio fluctuations observed in annual harvests (Table 5) must, therefore, reflect different numbers of bears in the behavioral groups. Sex ratios in 1966 to 1968 suggest the synchronous reproductive patterns noted by Free (1968) for New York State bears. However, the distribution of the bear harvest shifted from areas close to Valdez in 1966 and 1967 to distant rarely hunted areas in 1968 and 1969 (Table 4). Possibly a large population of relatively vulnerable males was exposed to hunting pressure, and its numbers in the harvest obscured the effects of synchronous reproduction on the sex ratio in 1969 and possibly in 1968.

The hunter-harvest sample of the black bear population is biased, as evidenced by the sex ratio. However, the bias apparently reflects regional differences in bear availability and correlates with different hunting intensities. Time and space-relative comparisons of age and abundance with hunting pressure should not be affected.

The mean litter size of 14 sow-cub groups was 1.85 first-year cubs per litter. This may be an underestimation. It is difficult to see all of the cubs when they are in partial cover. As an example, two cubs were seen in the first two observations of a sow-cub group on an island. On the third observation, as the group was crossing from one island to another, the third cub was observed. Although little information is available on productivity and bear movements, population recruitment has apparently not kept pace with bear removal in heavily hunted areas.

## CHARACTERISTICS OF THE HUNTER HARVEST

Much of the hunting in the vicinity of Valdez has been incidental to other recreational activity. Initially, hunters were mainly civilians from Fairbanks and Anchorage, some being present in response to the area's growing reputation for good black bear hunting. The Valdez Army Recreation Camp opened in 1962 and provided boat transportation and lodging for military personnel. The number of black bear hunters increased markedly in subsequent years, and military personnel composed the bulk of the hunters. In recent years an increasing proportion of resident and nonresident civilians and military personnel went on guided hunts.

The black bear hunting season in Valdez extends from September through June. Because of winter dormancy, the hunting season is in two parts - the spring and fall seasons. The bag limit per year was three bears from 1958 until the fall hunt of 1966, two bears from the fall of 1966 until the fall of 1969, and one bear per year since then.

### Spring Hunt

The categorization and relative success of spring black bear hunters are compared for the years 1966 through 1969 in Table 7. The success of unguided hunters has declined, although the success of guided hunters has remained high. The relative proportion and absolute number of bears killed by guided hunters has increased with the result that more bears have been killed in distant areas in recent years. This spatial shift of hunting pressure, coupled with a greater reliance on

Table 7. Characteristics of Valdez-based black bear hunters for the spring seasons of 1966 to 1969.[a]

| | 1966 | 1967 | 1968 | 1969 |
|---|---|---|---|---|
| Hunter Success, Percent | | | | |
| Unguided Hunters:[b] | 57 (51) | 51 (55) | 17 (76) | 16 (95) |
| Guided Hunters:[b] | | 55 (22) | 65 (29) | 39 (51) |
| Mean Number Hunting Days per Kill, Unguided: | 3.3 | 4.4[c] | 13.4 | 23.6 |
| Bears Killed, | | | | |
| Unguided Military: | ca. 50 | 19 | 11 | 13 |
| Valdez Residents: | 5-10 | 2 | 0 | 0 |
| Unguided Civilians: | 15 | 7 | 8 | 2 |
| Guided Hunters: | 10 | 12 | 29 | 20 |
| Total | 80-85 | 40 | 48 | 35 |
| Percent of Bears Killed by Guided Hunters: | 12 | 30 | 60 | 57 |
| Location of Kill, Distance from Valdez | | | | |
| 0-30 miles (0-48 km): | 70-75 | 28 | 19 | 6 |
| 31-80 miles (49-130 km): | 10 | 12 | 29 | 29 |

[a]Data for 1966 and 1967 are from Grauvogel (1967).

[b]Numbers in parentheses refer to the total number of hunters included in the sample.

[c]Value includes hunting days of guided hunters.

experienced guides, has maintained a higher total bear harvest than if hunting pressure had been confined to one area.

The mean length of a hunt in 1968 was 2.3 days; in 1969, 3.9 days. Some of the unguided hunters in 1969 traveled to more remote locations and hunted for a longer time. Relatively more of these hunters were successful (Table 4).

Although only a few charter boat operators guided hunters in 1968, the opportunities for guiding increased in 1969 as indicated by the number of guided hunters shown in Table 7. An increasing number of Valdez boat operators carried one or more hunting parties in the spring hunt. Client success of the more experienced guides was four times higher than the mean for clients of inexperienced guides. Besides experience, however, some of the inexperienced charter boat operators attempted to legally charter their boats without also guiding, and client success in these cases was especially low. As a result, overall success of guided hunters declined in 1969.

Most of the spring black bear hunting occurred between the second and fourth weeks of May in 1969. In contrast, peak numbers of hunters in 1968 occurred over the Memorial Day weekend. Hunters arriving in early May were more successful than hunters arriving in late May in 1968.

Lingering winter conditions in 1966 may have increased the bear harvest (Grauvogel, 1967). However, weather and phenology were similar from 1967 through 1969 (Dallas Benedict, pers. comm.), and hunter success continued to decline. Valdez weather station data on spring snow accumulations and rate of snow melt did not correlate with bear harvest data for the period 1966 to 1969.

Fall Hunt

Fall hunting data for 1966 to 1969 are presented in Table 8. No data are available for the fall hunt of 1967 except that one guide's clients are known to have taken 11 bears. A high proportion of hunters in 1968 and 1969 is accounted for. Examination of the data shows a decline in hunting success followed by a decline in hunting pressure. All bears killed in 1968 and 1969 were taken by guided parties hunting in remote areas.

Discussion: Black Bear Life History and Hunting Pressure

Although several color phases of the black bear are reported for Alaska (Erickson, 1965), almost all of the coastal black bears seen in the Prince William Sound vicinity were "black". Male black bears are noticeably larger than females (Cahalane, 1961; Hatler, 1967) which could have provided a basis for hunter selection (Troyer and Hensel, 1964). However, as previously discussed, hunter selection was probably infrequent for black bears in the study area. Black bears have long guard hairs covering an underfur (Matson, 1967) and seem indifferent to varieties of summer weather - they were often seen feeding in cold, rainy weather that discouraged hunting. The spring coat differed from the fall coat, being longer and duller (fall coats were glossy). Most hunters seemed unconcerned with seasonal differences in pelage quality.

It is unclear whether bears have poor vision (Matson, 1967) or whether they are mainly visually concerned with their immediate surroundings. Various incidents suggested that bears were not myopic.

Table 8. Characteristics of Valdez-based black bear hunters for the fall seasons of 1966 to 1969.[a]

| | 1966 | 1967 | 1968 | 1969 |
|---|---|---|---|---|
| Unguided, | | | | |
| Hunter Success, Percent:[b] | 75 (16) | | 0 (27) | 0 (3) |
| Number of Hunter-days: | 37 | | 84 | 9 |
| Number of Bears Killed: | 14 | | 0 | 0 |
| Mean Number Hunting Days per Kill: | 2.6 | | | |
| Total Bear Kill, Guided and Unguided: | ca. 30 | 11+[c] | 2[c] | 6[c] |

[a]Data for 1966 are from Grauvogel (1967).

[b]Numbers in parentheses refer to the total number of hunters included in the samples.

[c]All bears were killed by guided hunters; the total bear kill by guided and unguided hunters in 1967 is unknown.

Bears did appear, however, to rely greatly on their senses of hearing and smell. Consequently, black bears feeding on tidal marshes and clearings could be approached from downwind relatively easily, but a hunter–black bear encounter in heavy cover was infrequent.

Black bear movements are primarily controlled by available food and cover (Matson, 1967; Troyer and Hensel, 1964). For bears, food supply and cover are mainly functions of vegetation which varies greatly in the study area with climate and topography. The outstanding physical features have been described but can be summarized here. The snow-capped land ridges caused abrupt differences in vegetation between sea level and alpine peaks, and climate varied between north and south-facing slopes. The oceanic influence caused high precipitation, relatively even temperatures, and early snow melt close to the waterline.

The first areas free of snow are low altitude clearings and colluvial slides on south-facing slopes, and the first bears seen are in these areas eating mainly Gramineae (Dallas Benedict, pers. comm.; Clark, 1957). In early spring, bears on south-facing coastal slopes were concentrated by the snow and available food and were exposed since the deciduous vegetation had not leafed out. The high hunting success in past years near Valdez rested largely on bear vulnerability in these circumstances. As the snow receded later in the season, some bears followed it up the slopes feeding on the emerging vegetation. The total apparent bear density decreased since the animals were less exposed to view, were scattered over a larger area, and were feeding in areas further from the majority of boat-transported hunters. Cover continued to increase as <u>Alnus</u> leafed out, forbs gained height, and snow melted under the conifers. Hunters seeking bears on coastal slopes during the latter part of May had little chance of success.

It was in mid-to-late May, however, that bears were frequently seen feeding on tidal marsh vegetation and along shorelines. The past success of guided hunters rested mainly on hunting bears that fed on tidal marshes. Hunting success remained high through the first week of June and then declined.

In summary, spring hunting pressure has been effective mainly because of the vulnerability of bears (i) in clearings and on colluvial slide areas on low altitude south-facing slopes and (ii) on tidal marshes. Hunting in other areas has been generally unproductive. Perhaps the most important question unanswered by this study is what proportion of the bear population feeds in these areas. Because bear movements within timbered areas could not be observed, speculation is hazardous. A large portion of the coastal slope is distant from tidal marshes, has a rocky shoreline, and is screened from hunters by coniferous trees growing along the shoreline. Bears staying within these areas are not vulnerable to hunting pressure. For example, few bears have been killed on the north-facing coastal slope of Port Valdez. Bear densities appeared lower in these areas, however.

Spring bear hunting was virtually over by mid-June. Bear sign was distributed almost evenly from sea level to timberline. Bears in diverse habitats appeared to be eating those food items which were most available. With the arrival of spawning salmon in July, an unknown proportion of bears fed heavily on this food source. By fall, most bears were distributed within heavy cover and were feeding on

*Vaccinium* berries.

Fall hunting success was poor in 1968 and 1969. This poor success was partially due to the distribution of black bears in heavy cover. Some guides obtained bears for their clients by watching tidal marshes and areas adjacent to the mouths of salmon spawning streams, and other guides hunted in inland locations along the margins of these streams. The high hunting success of unguided hunters in 1966 relative to 1968 probably reflects differences in black bear abundance.

Bear movements are probably limited by their habitat preference and the regional topography. Coastal black bears were seldom found far from timbered areas. The extent of lateral movement along coastal slopes is unknown. Although bear sign has been seen on mountain peaks and bears frequently feed in subalpine areas, true alpine areas probably restrict bear movements. Similarly, bears will swim across large stretches of open water (Skinner, 1925), but they generally do not do so. Bears inhabiting timbered slopes delimited by alpine ridges and bay waters can be considered semi-isolated populations. Natural reestablishment of these populations after overhunting will probably be slow.

## MANAGEMENT IMPLICATIONS

Coastal black bear densities near Valdez have apparently declined substantially within the past few years. The vulnerability of black bears to hunting, their restricted immigration into hunted regions, and the rapidly increasing number of hunters in recent years are important factors to consider in management. On the other hand, hunting pressure has only been effective in areas with a characteristic vegetation and topography. In addition, there are indications of a decrease in hunting pressure following a decrease in hunting success. If numbers of unguided hunters remain at levels seen in the past few years, it seems possible that bear densities near Valdez will not continue to decline. For example, bear density on the mountain adjacent to Valdez and in Mineral Creek canyon was assessed at 1.4 bears per square mile; yet only two bears were killed in the vicinity of Valdez in 1968, none in 1969. In addition, the mean age of bears killed in the Port Valdez-Valdez Arm region was 6.9 years. The mean age of bears harvested in Pennsylvania in 1967 was less than five years (Wakefield, 1969). By comparison with Pennsylvania, these Prince William Sound bears were relatively old.

The differences between the contiguous states and the Prince William Sound area in hunting techniques and hunting pressure should be emphasized. Hunters in the eastern United States are often densely distributed in accessible hunting areas, and much bear hunting is incidental to deer hunting. Many bears are probably aroused by one group of hunters and moved from hunter-to-hunter until they are killed. Hunting pressure is maintained even with low hunter success because of the attraction of the alternate game species. In contrast, black bear hunters in the study area generally hunted from their boats, and there was no alternate big game species in most of the Prince William Sound region.

In terms of maximum utilization of the resource on a sustained yield basis, there appears to be no justification for additional restrictions on unguided hunters.

Most of the bears killed by guided hunters were illegally taken. As previously discussed, many of the Valdez boat owners were not aware of the legal difference between chartering their boats and guiding. Others were aware of this technicality, but the incentive to guide was great and enforcement of regulations has been nonexistent. There are good reasons, aside from legality, for enforcing the statute. The price quoted by at least one guide for a black bear was one hundred to two hundred dollars, guaranteed. This can be a lucrative commercial enterprise. The quality of the sport is low from a traditional concept. Some bears were reportedly shot from boat decks. Hunters frequently remained inside a heated boat cabin until the guide sighted a bear. Subsequent hunting often consisted of riding a small boat to a tidal marsh and then following the guide to within close range of the bear before shooting. Licensed guides may pay a large fee to charter boat operators for transportation, then compete with other charter boat operators who are not licensed guides. This is unfair to licensed guides.

A logical first step in curbing illegal guiding is a public information program designed to inform Valdez boat owners of the difference between guiding and chartering. A second step would be to publicize intent to enforce existing regulations. Continued illegal guiding can be expected to be concentrated in the Unakwik Inlet vicinity (Fig. 4). Spring guiding has occurred between the first week of May and the second week of June; fall guiding in the first two weeks of September. Sites of kills have mainly been tidal marshes in the spring and tidal marshes in the fall if salmon spawning streams were nearby. Alaska Fish and Game Department enforcement personnel stationed near these sites could apprehend charter boat operators who are illegally guiding. A program of information and enforcement similar to the one described should sharply curb illegal guiding.

The black bear situation in the vicinity of Valdez seems to require a different management approach. During the time of the study, businesses catering to outdoor recreationists and tourists were probably the main industry of Valdez. As a corollary to the importance of recreation to Valdez, the city was an important stopover for many tourists. The attractions have been the spectacular scenery and the wildlife. Spawning salmon, mountain goats which are visible on peaks adjacent to Valdez, and migratory waterfowl stopping at Robe Lake and on tidal marshes continue to be tourist attractions. The situation with respect to bears has deteriorated. Long-time residents of Valdez reported that it would have been unusual to drive up Mineral Creek road and not see black bears on the colluvial slides in the late 1950's. Since the decline of black bear numbers, the attitudes of some Valdez residents towards military hunters are not friendly. Two brown-grizzly bears (Ursus arctos) were frequently seen in 1969 near the terminus of the Robe River. An observation of these bears is a moment of remark, even to Valdez residents. Certainly the sighting of one of these brown-grizzly bears was the climax of many a tourist's vacation. Yet, the very frequency of contact makes it unlikely that these bears will survive many more hunting seasons.

Valdez was designated in 1969 as the southern terminus for the pipeline system that will carry oil from the arctic slope oil fields. The development of the oil port facilities and the shipment of oil will probably displace tourism as the leading industry of Valdez, but tourism will undoubtedly continue to increase in importance. Management of wildlife in the vicinity of Valdez for the tourist, as a nonconsumptive user, would appear to be an increasingly important objective. The utilization of wildlife in the immediate vicinity of Valdez for aesthetic enjoyment currently surpasses its value for hunting (only two bears were killed in the vicinity of Valdez since 1968). It is apparent in the case of bears that hunting and nonconsumptive utilization are incompatible. Mineral Creek canyon, the mountain adjacent to Valdez, Airport Road including the Valdez campground and the terminus of the Valdez Glacier, Robe Lake, Robe River, and the lower portion of the Lowe River (Fig. 2) should be closed to all hunting. The protection of wildlife species close to Valdez, hopefully with a restored abundance of bears, should result in an increased availability of wildlife for nonconsumptive users. Such a proposal is in keeping with Alaska's general policy of tailoring wildlife regulations to benefit regional needs.

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