AN EVALUATION OF SELECTIVE BULL MOOSE HARVEST ON THE KENAI PENINSULA, ALASKA

Charles C. Schwartz, Kris J. Hundertmark, and Ted H. Spraker
Alaska Department of Fish and Game, 34828 Kalifornsky Beach Rd, Suite B, Soldotna, AK 99669

ABSTRACT: Low bull:cow ratios (5-12 bull:100 cows) on the Kenai Peninsula prompted the Alaska Board of Game to institute a selective harvest system (SHS) for bull moose (*Alces alces*) in 1987. Under SHS only those males with spike or forked antlers (yearlings) or bulls with antlers greater than or equal to 50 inches in spread or with three tines on one brow palm were legal. Population and harvest statistics for 5 years prior to SHS were compared to the first 5 years of SHS. Total bull harvest (636 vs. 443 moose) and the number of hunters (3602 vs. 2605) declined significantly ($P<0.05$) under SHS. However, hunter success did not change (18 vs 16%). Population modeling was useful to demonstrating to the public anticipated declines in the moose harvest and changes in the bull:cow ratios following implementation of SHS. Modeling accurately predicted both harvest and changes in bull:cow ratios following both normal and severe winters. Based on harvest statistics approximately 34, 79, 47, and 19% of yearling, 2-3, 4-5, and bulls greater than 6 years of age, respectively, were protected under SHS. The reported illegal harvest of 7% of the legal kill under SHS was mainly sub-legal bulls mistaken for larger antlered animals. The bull:cow ratio increased from 16 bulls:100 cows to 29 bulls:100 cows 3 years after implementation of SHS. As the number of bulls in the population increased, no changes in calf:cow ratios, pregnancy rates, or sex ratio of calves was detected. SHS is an alternative to the traditional any bull season. The harvest system allows for unlimited hunter participation, optimizes recreational opportunity, and precludes the need for more restrictive seasons usually applied after severe winters. Management implications and recommendations are discussed.

ALCES VOL. 28 (1992) pp. 1-13

Harvest of moose occurs throughout Alaska where a surplus of animals exists. In areas with heavy hunting pressure, it is traditional practice to restrict or direct this harvest to the male segment of the population (Timmermann 1987). The harvest of bulls with spike-forked (S-F) antlers was implemented in central British Columbia to limit harvest of bull moose in heavily hunted areas (Child 1983, Child and Aitken 1989).

Intensive harvest of bull moose on the Kenai Peninsula, Alaska in the late 1970's and early 1980's resulted in a low proportion of bulls in the population. Ratios at that time varied from 5 to 12 bulls:100 cows in areas with good access and heavy hunting pressure. Concern for the population and further hunting opportunity, coupled with the desire to view more bull moose prompted the Alaska Board of Game to instituted a selective harvest system (SHS) in 1987. Under SHS, the only legal bull was a spike-fork moose (yearling) or a bull with antlers greater or equal to 50 inches.

The Board's objectives of SHS were to: (1) increase the bull:cow ratio, (2) increase the number of prime bulls in the population, (3) increase the opportunity to view bull moose, (4) maintain hunting opportunity, and (5) promote hunter ethics.

Objectives of this study were to evaluate the effects of a SHS hunting season on: (1) total moose harvest, (2) hunter participation, (3) illegal harvest, (4) age distribution of harvested animals, and (5) herd composition.

In populations with few bulls, it has been hypothesized that the remaining adult males could not breed all of the females (Rausch *et al.* 1974) or that some females may not get bred during their first estrus (Rausch 1965). Speculation about second estrous breeding was supported by plots of fetal size and age

(Edwards and Ritcey 1958), and observations of small calves weeks after the peak in calving (Bailey and Bangs 1980). Consequently, we also investigated changes in pregnancy rates, conception timing, and changes in sex ratio of calves as the bull:cow ratio increased after implementation of SHS.

METHODS

Harvest and Hunter Statistics

Prior to 1987 in Game Management Units 7 and 15 on the Kenai Peninsula, any bull moose was legal for harvest during the September 1-20 hunting season. Beginning in 1987, harvest was restricted to bulls with antlers of the S-F architecture *or* with antlers having a width equal to or greater than 50 inches or with three tines on one brow palm. A S-F antler was defined as having only one or two tines (Fig. 1); male calves were not considered legal spike-fork bulls. A tine was defined as an antler projection which was at least one inch long, and which was longer than wide when measured one inch or more from the tip. A 50 inch moose was a bull with an antler spread of 50 inches or more, or with 3 or more tines on either brow palm. Bull moose with either of these antler types were considered legal under SHS (Fig. 1).

The moose harvest was monitored by the Alaska Department of Fish and Game (ADF&G) using a harvest report card system. Each hunter was required to obtain a moose harvest ticket prior to participating in the hunt. The harvest ticket contained a harvest report card. Hunters were required to complete and return the report card to ADF&G within 15 days after a successful hunt or within 15 days after the close of the season, even if unsuccessful. Hunters failing to report were sent a reminder letter. As a result of the second mailing, the overall reporting rate was high ($\bar{x}$= 70%, range 68-72%, years 1983-90) and consistent among years. Hunter reports provided information on effort, location of kill, success rates, method of take, means of transportation, and a measure of antler spread and number of brow tines on each set of antlers.

We compared total harvest, hunter participation, and success rates during the first 5 years of SHS with the 5 years prior to SHS with *t*-tests. Due to inadequate funding, no formal survey was conducted to assess hunter attitudes on SHS, or changes in hunter perception over time. We did however make numerous informal contacts with members of the hunting and non-hunting public. We present the results of these informal 'surveys' in this paper.

Age Distribution of Harvested Animals

Hunter check stations were established by the Kenai National Wildlife Refuge in 1984, in cooperation with ADF&G at 3 strategic locations. Check stations were operated during periods when most hunters were expected to be entering or leaving the field. All hunters were requested to report. Antlers were measured and classified as spike, fork, or palmated (>spike or fork). Two incisor teeth were extracted for age determination for all bulls with a complete set of permanent incisor teeth. Males with deciduous incisors were considered yearlings (Peterson *et al.* 1983). Extracted teeth were sectioned and cementum annuli were counted (Sergeant and Pimlott 1959).

We converted the antler size listed on harvest reports to age classes using the distribution of antler size by age of bulls collected at the check stations from the 1984-86 (Fig. 2). We used this distribution to assign age class to all harvest recorded. We assumed that all bulls with an antler spread of 29 inches or less were yearlings, whereas 46% of the 30-34 inch bulls were yearlings but 54% were ages 2 and 3 years (Fig. 2). These converted data were used to estimate the age structure of the harvest.

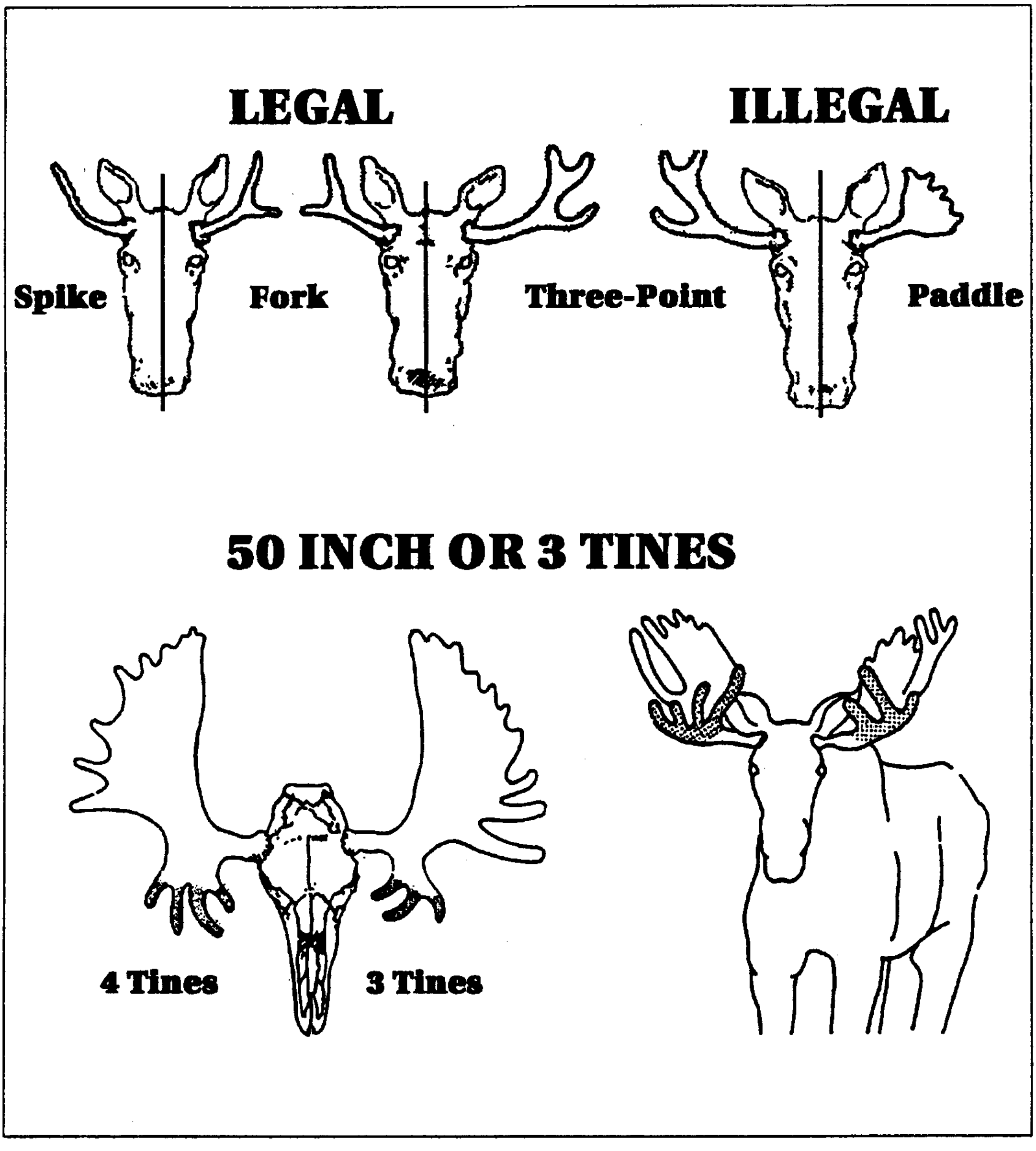

Fig. 1. Moose with a spike or fork antler, with antlers greater than or equal to 50 inches in spread, or with 3 tines on at least one brow palm were legal under the selective harvest system on the Kenai Peninsula, Alaska.

Illegal Harvest

Statistics on the number of illegal moose killed during the regular hunting season were obtained from the records of Fish and Wildlife Protection (FWP), the law enforcement branch in charge of wildlife violations in Alaska. Information on illegal kill was actual cases investigated by FWP officers, verified reports received from the public, and cases reported to official check stations. This information represents an undetermined proportion of the total illegal harvest.

Sex and Age Composition of the Population

Sex and age composition of the population were determined each autumn from composition counts (Bishop and Rausch 1974). Males were classified according to antler size:

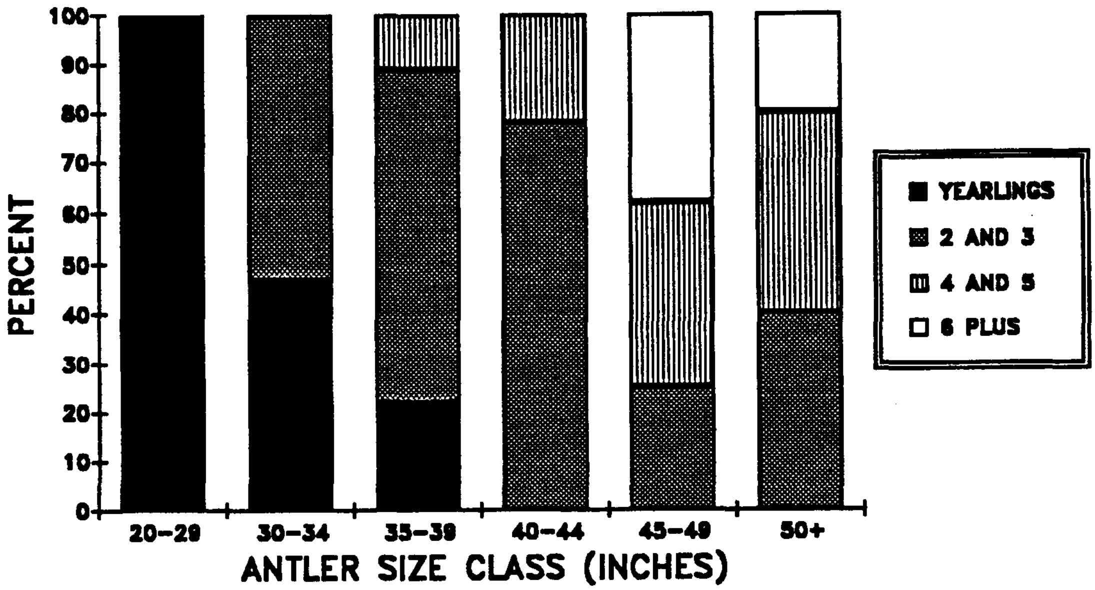

Fig. 2. Proportion of antler size classes by age classes of bull moose on the Kenai Peninsula, Alaska.

small (<30 inches), medium (31-49 inches), and large (≥50) bulls. Total calves in the herd were estimated from the ratio of calves per 100 female. Because of poor survey conditions, composition counts were not conducted in 1984 and 1986.

Count areas ranged from 50 to 1680 km^2, and were relative uniform physiographically, with easily recognizable boundaries. Not all areas were surveyed each year prior to implementation of SHS. We compared herd composition during the 5 years prior to SHS (1982-86) with the first 5 years of SHS (1987-91).

Pregnancy Rates and Calf Sex Ratios

From 1987-92, we collected the reproductive tract and lower jaw from cow moose killed by automobiles. Collection began in late-November when embryos were sufficiently developed to determine sex from external genitalia. Each fetus was removed from the uterus, and weighed and measured (Markgren 1969). Dates of conception were determined using the sigmoidal growth equations presented by Schwartz and Hundertmark (1993).

Sex ratio of calves was estimated in spring 1988 during the calving season in an area known as the 1969 burn. Calves were captured using helicopter techniques (Ballard *et al.* 1979), sexed, ear tagged, and released.

Differences in pregnancy rates, conception dates, and fetal sex ratios among years was tested using the G-test (Sokal and Rohlf 1981). Overall deviation from a 1:1 sex ratio among fetuses was tested with a binomial test (Siegel 1956).

Population Modeling

To help us predict the anticipated changes in harvest and bull:cow ratios, we developed a discriminate model using the software package Lotus 123. Inputs to the model were survival coefficients (birth to fall, hunting season, overwinter) by sex and age class (Table 1), sex ratio of calves at birth (60:40 M:F) (Franzmann and Schwartz 1986), and twinning rate among reproductively active females (age > 2, 40%) (Schwartz and Franzmann 1989). We set initial inputs to those of the existing population prior to SHS. The population of 3450 animals had a bull to cow ratio of 12 bulls:100 cows and 26% of the

Table 1. Input use for the deterministic model used to predict outcome of the selective harvest of moose on the Kenai Peninsula, Alaska.

	Percent Surviving				
	Summer	Hunt		Winter	
Age Class		Regular	SHS	Normal	Severe
Calf	55	100	95	36	10
Yearling	95	46	55	84	79
Adult	99	53	55-95[1]	99	94

[1]Survival for age class 2 and 3, 4, 5, and ≥6 was 95, 85, 75, and 55 percent respectively.

population was calves. A series of model runs was conducted until we developed a stable population with herd composition identical to pre-SHS in the Subunit 15A. The population was basically stable ($X = 0.997$). To simulate anticipated changes with implementation of the SHS, we altered survival coefficients for males, reducing hunting mortality for age classes 2 - 5 (Table 1). No changes in reproduction were made.

We also simulated the effects of a severe winter on changes in harvest and herd composition. To do this we reduced winter survival rates for calves from 0.36 to 0.10. This resulted in an annual survival rate of 5.5% which closely approximated that witnessed following a severe winter. In addition, we reduced adult survival during winter by 5% for each sex-age classes. We simulated a severe winter during year 3 of SHS because of the occurrence of a severe winter in 1989-90, the 3rd year of SHS.

RESULTS AND DISCUSSION

Harvest Statistics

The mean harvest of bull moose on the Kenai Peninsula prior to SHS was 636 animals (range 486-755, 1982-86). This harvest was significantly higher ($P = 0.016$, $t = 3.04$, 8 df) than the harvest ($\bar{x} = 466$, range 362-582) after initiation of SHS (Fig. 3).

The simulation modeling exercise was very useful in projecting expected changes in both harvest and bull:cow ratios as a result of SHS. In Subunit 15A, using the model, we projected that bull harvest would decline by 43% the first year of SHS (Fig. 4A). The actual decline was 48%. Harvest was projected to gradually return to within 17% of pre-SHS level 7 years after implementation of the hunt. Projected harvest was expected to remain below pre-SHS due to: (1) natural mortality in all age classes of bulls, (2) illegal harvest of sub-legal bulls, and (3) natural declines in the moose population with forest maturation (Loranger *et al.* 1991).

The winter of 1989-90 was extreme, with deep snow that remained from early-December until late-April. A high mortality of moose resulted in Subunit 15A. Pre-winter composition counts indicated that the moose population contained about 40 calves:100 cows. A census conducted in February revealed that most of the calves (95%) had died. In addition to the loss of calves, an unknown number of adults also died from starvation. In addition, a record number of moose (366 vs. $\bar{x} = 216$, 1984-89) were killed by collision with vehicles on the Kenai Peninsula (Del Frate and Spraker 1991).

Using the model, we projected the effects of this severe winter in Subunit 15A (Fig. 4B). Projections suggested that bull harvests would decline 63% from the pre-SHS kill. Actual recorded harvest declined 66%. Harvest was also projected to increase 96% the following year. The actual increase was 87%.

Total moose harvest on all of the Kenai

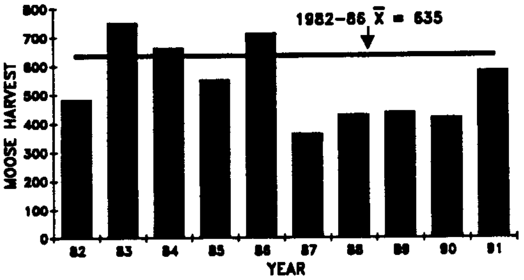

Fig. 3. Annual moose harvest prior to selective harvest system (1982-86) and following implementation SHS in 1987. Harvest under SHS was significantly lower.

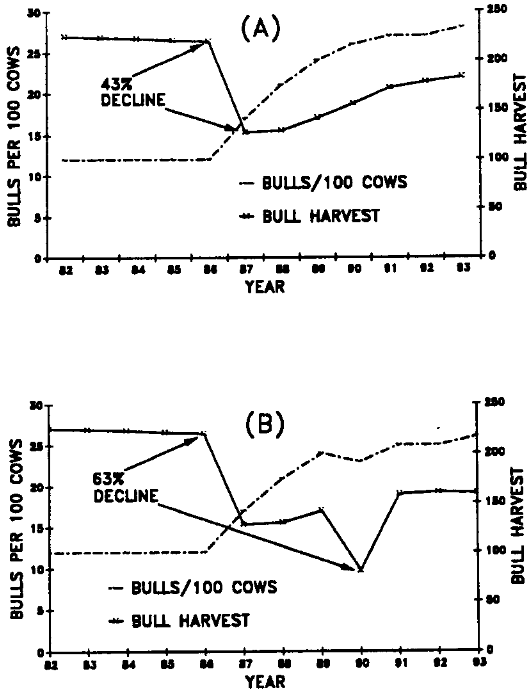

Fig. 4. Projected changes in bull harvest and bull:cow ratio using a discriminate model following normal winters (A) and the severe winter of 1989-90 (B).

Peninsula did not decline following the severe winter of 1989-90, because of the high harvest in Subunit 15C. This area did not experience the degree of severe winter or deep snows of the northern peninsula.

Hunter Participation and Attitude

There was a 24.6% ($P = 0.008$, $t = 3.54$, 8 df) decline in the number of people hunting after implementation of SHS ($\bar{x} = 3602$, range 2827-4018 vs. $\bar{x} = 2716$, range 2494-3204) (Fig. 5). Some people indicated that they were not willing to participate in such a restricted hunt. Others were uncomfortable about identifying a legal bull and consequently did not hunt. People choosing not to hunt under SHS apparently represented a cross section of all hunters since hunter success did not change significantly ($P = 0.30$, $t = 1.106$, 8 df) with implementation of SHS (18 vs. 16%).

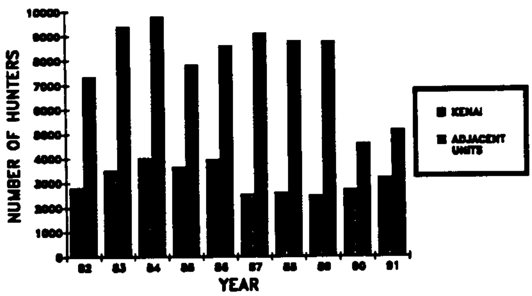

Fig. 5. Change in number of people hunting moose on the Kenai Peninsula, and adjacent areas following introduction of a selective harvest system in 1987 and severe winter in 1989-90.

Hunters not participating in SHS on the Kenai Peninsula apparently did not travel to adjacent Units to hunt moose. The total number of moose hunters in adjacent road-accessed areas (Game Management Units 16A, 13, and 14) did not increase significantly ($P = 0.33$, $t = 0.045$, 6 df) following initiation of SHS (Fig. 5). We did not include years 1990 and 1991 in these calculations because moose seasons in these Units (16A, 14, 13) were either severely restricted or closed following the severe winter of 1989-90. Hunter numbers in these Units declined significantly ($P < 0.001$, $t = 16.09$, 3 df) from 8883 in years 1987-89, to 4894 in years 1990-91 as a result of season restrictions.

Interviews with hunters at check stations and public meetings suggested that most hunters supported inception of SHS but were somewhat intimidated when faced with the need to determine what bulls were legal for harvest. Some felt so unsure about making a correct identification of antler size that they did not hunt on the Kenai Peninsula. As the Department's objective was to increase hunting opportunities, an extensive educational program was initiated prior to the 1989 hunting season to improve hunter confidence and familiarity with the benefits of SHS. Hunters were trained to identify a legal bull. An antler display showing legal and illegal bulls was installed at shopping malls in local communities for educational purposes. Although we had no direct way of judging the program's effect, we felt it was a success based on feedback from individuals (1) who had initially quit hunting because of SHS but started again, (2) increased confidence displayed by hunters who attended the public information/education meetings, and (3) initial reduction in the illegal kill.

Age Structure of Harvested Males

Prior to initiation of SHS, the distribution of the bull harvest was comprised of 46% yearlings, 38% 2-3 year-olds, 11% 4-5 year-olds, and 5% moose ≥6 years of age. Following implementation of SHS, 64, 17, 12, and 7% of the harvest was yearlings, 2-3, 4-5, and ≥6 year old moose, respectively (Fig. 6). The distribution shifted significantly toward yearlings ($X^2 = 137.1$, $P = 0.001$, 3 df) and away from age class 2-3. There was, however, little change in the proportion of the harvest comprised of bulls ≥4 years of age.

The percentage decline in harvest by age class indicates the proportion of bulls protected under SHS. For example, there was a 34% decline in the annual harvest of yearlings. Based on check station data collected from 1982-83, we estimated that approximately 50% of the yearlings in the population possessed antlers with architecture greater than either spike or fork and therefore would not be legal for harvest under SHS. Actual data for the 1987-91 regulation period indicate that this estimate was high.

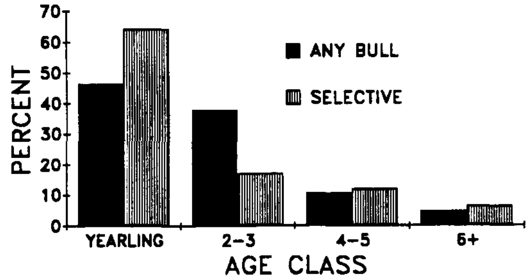

Fig. 6. Proportion of bull moose by age class harvested under an any bull season (1983-86) and under a selective harvest system (1987-91), on the Kenai Peninsula, Alaska.

The greatest change (79% decline) in annual harvest was in the 2 and 3 year-old age class. This decline was anticipated since all antlers in this age class were larger than spike-fork and most were less than the 50 inches in width required or had fewer than 3 brow tines. Information from the check stations indicated that prior to 1987, 19% of all bulls greater than 1 year of age had antlers less than 50 inches but had at least one brow palm with 3 tines. There was also a 47 and 19% decline in harvest of bulls in the 4-5 and ≥6 age classes, respectively. But, we expect these values will decline as younger bulls mature and are recruited into the older age classes and become legal to harvest under SHS.

Our estimates of changes in absolute harvest are somewhat inflated because they assume a constant population from 1983-1991. The population probably declined slightly following the severe winter of 1989-90. Also, natural succession has resulted in a net decline in moose numbers (Loranger *et al.* 1991).

Check station information indicated that in a historically high harvest area the proportion of bulls with antlers ≥50 inches were similar to the pre-SHS sample (4%). The balance of the harvest (16%) was of animals with antlers less than 50 inches in spread but with at least 3 tines on one brow palm of one antler.

Illegal Harvest

The number of reported illegal moose changed with initiation of SHS. Prior to SHS any bull was legal, so illegal harvest was mainly females. From 1982-86, the illegal take of cows represented 5% of the known legal harvest of bulls.

With the initiation of SHS, the illegal harvest of cows declined from an estimated 30 per year to less than 10. Concurrent with this decline in illegal cow harvest there was an increase in illegal harvest of bulls (Fig. 7). Most of the illegal bulls shot were mistakenly identified by hunters as large bulls. Hunters commonly made mistakes when counting the number of brow tines. Reported illegal kill during the first 5 years of the SHS program averaged 7% of the legal harvest.

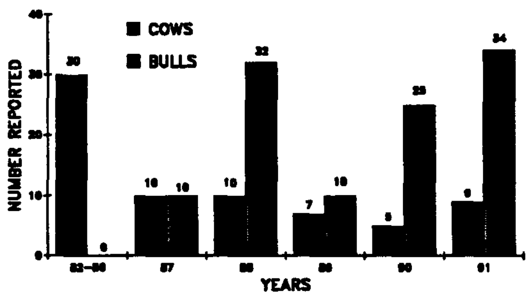

Fig. 7. Reported illegal harvest of bull and cow moose on the Kenai Peninsula, Alaska. Starting in 1987 a selective harvest system was implemented. Prior to that any bull was legal to harvest.

The education program to train hunters to identify a legal bull was implemented prior to 1989. That fall the number of bulls that were illegally shot declined. However, this was short lived since the illegal harvest increased in 1990 and in 1991. The initial reduction in the illegal kill suggested that either: (1) a continuous educational effort was required, or (2) the educational program had little effect and the low illegal kill in 1988 was a spurious event. The effectiveness of educational programs to reduce illegal kills needs further study.

Sex and Age Composition of the Population

A major objective of SHS was to increase the ratio of bulls:100 cows. The bull:cow ratio increased significantly (P = 0.012, t = 3.574, df = 6) as a result of SHS (Fig. 8). Prior to SHS, mean ratio was 16 bulls:100 cows. The mean ratio for the 5 years of SHS was 25 bulls:100 cows. The bull:cow ratio increased to 29 in 1989, but declined slightly in 1990 and 1991. This decline was a direct result of high calf mortality during the severe winter of 1989-90. Because most calves died in Subunit 15A, very few yearling bulls recruited into the population the following year. Composition counts reflect this loss.

With the protection of large-antlered yearlings (3 or more points) and most bulls with antlers up to 50 inches in spread, viewing opportunities changed from uncommon to common. People began seeing bulls during and after the hunting season in areas where bull sightings were rare prior to SHS. The public appreciation of seeing bull moose resulted in increased support of the SHS program.

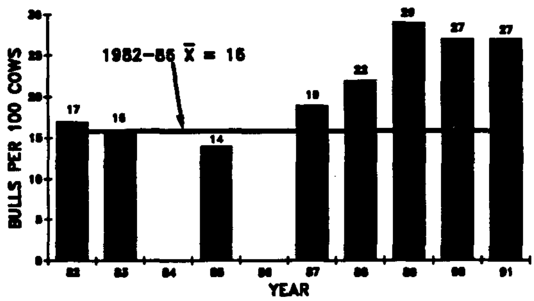

Fig. 8. Comparison of the bulls:100 cows ratio on the Kenai Peninsula, Alaska prior to (1982-86) and following (1987-91) implementation of a selective harvest system on bull moose.

Cow:calf Ratios

We did not detect a significant difference (P = 0.33, t = 1.07, 6 df) in the ratio of calves:100 cows following implementation of SHS (Fig. 9). There was a decline in the cow:calf ratio following the severe winter of 1989-90, but we attributed this to poor re-

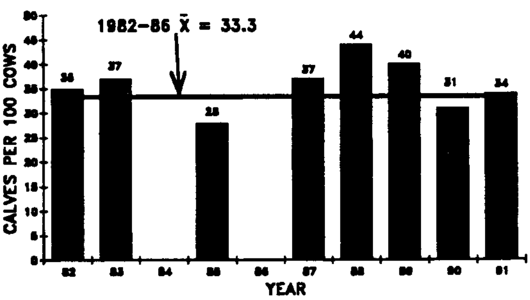

Fig. 9. Comparison of calves:100 cow ratio on the Kenai Peninsula, Alaska, prior to (1982-86) and following (1987-91) implementation of a selective harvest system on bull moose.

cruitment of calves following that severe winter.

There is a high rate of mortality in neonatal calf moose on the Kenai Peninsula (Franzmann *et al.* 1980, Franzmann and Schwartz 1986, Schwartz and Franzmann 1989). Nearly 50% of all calves are dead before fall composition counts are conducted. This high mortality masked our ability to measure any change in reproductive performance associated with increasing bull:cow ratios following implementation of SHS.

Pregnancy Rates, Conception Timing, and Calf Sex Ratios

The mean number of moose killed during the 1984-89 period on the road system on the Kenai Peninsula was 216; cows comprised roughly 39% of this kill (Del Frate and Spraker 1991). We were able to collect 129 reproductive tracts.

The average pregnancy rate over all years was 82% (n = 129) when cows of all ages were considered and did not differ significantly among years (G = 10.71, P = 0.22). Pregnancy rate for known age cows (n = 108) was 80% and increased to 90% when yearlings (n = 17) were excluded from the sample. Yearling pregnancy was 24%. Pregnancy rates for adult cows (>1) did not differ significantly among years (1987-91) (G = 4.19, P = 0.38).

Pregnancy rates of female moose on the Kenai Peninsula were similar to those reported elsewhere in North America (see Boer 1992). Moose are polyestrous, hence females not bred during their first estrus will breed in a subsequent cycle (*see* Schwartz and Hundertmark 1993). Hence, pregnancy rates probably do not change when bull:cow ratios become highly skewed. Consequently, we also examined the conception dates and the incidence of second estrous breeding.

By plotting fetal measurements against time of death, we were able to determine that 83% (n = 78) of all cows were bred during the first, 16 % (n = 15) during the second, and 1% (n = 1) during the third estrus. The proportion of cows breeding during each estrous period did not differ among years (G = 9.63, P = 0.313). It is of interest to note that 44% (4 of 9) of the fetuses measured in 1990-91 were probably conceived during the second estrous cycle. Because of small sample size, we were unable to detect a significant difference among years, even when the one 3rd estrous calf was combined with the 2nd estrous calves (G = 6.96, P = 0.14). This increase in later conception among cows may represent a delay in breeding associated with the poor condition of some females following the severe winter of 1989-90, rather than conception during a second estrous cycle. We do not know which. We do know however, that a large proportion of the sampled cows conceived much later than what was witnessed during other years of study.

The overall sex ratio of fetuses collected from the road killed cows was 1:1.16 (n = 132) in favor of males but was not different from unity (P = 0.342). Likewise, sex ratio did not differ from the binomial expectation (G = 4.96, P = 0.29) among years.

Similarly, the sex ratio of calves captured in the 1969 burn during peak calving season in 1988 (24-25 May), (29 males:21 females, n = 50) was not different from 50:50 (P = 0.32). A 33% twinning rate was observed for 82 cow:calf associations observed from a spotter plane (PA-18) and helicopter (Jet Ranger).

There was a shift in proportion of male calves in the population within the 1969 burn sometime between 1982-83 and 1988. A sample taken in 1982 and 1983 contained 64% male and 36% female calves and was significantly different than the expected 50:50 ratio ($n = 74$, $P = 0.027$) (Franzmann and Schwartz 1986). The twinning rate in 1982-83 was 70% (Franzmann and Schwartz 1985). We do not know why the sex ratio changed. We do not believe it was related to SHS since the ratio shifted one year after implementation of SHS and before there was any major shift in bull:cow ratios. We suspect that the twinning rate declined concurrent with successional changes in the 1969 burn. The moose population in this area peaked in 1983 (Schwartz and Franzmann 1989). Reduced twinning rated likely reflect declining habitat quality (Franzmann and Schwartz 1985).

MANAGEMENT IMPLICATIONS

Several advantages were identified in the SHS program. First, there was no need to restrict the number of hunters participating in the moose season. Second, because the harvest is targeted to a small segment of the male population, over-harvest is no longer of major concern. Third, there is no need to reduce season length following a severe winter when calf mortality is usually excessive. Such was not the case in other areas of Alaska where severe temporal restrictions or hunting closures were necessary. And fourth, under the SHS system, we were able to increase the number of bulls in the population. We selectively protected the most vigorous yearlings (those with large antlers), about 80% of the 2-3 year olds, and almost 50% of the 4-5 year olds. The increased bull numbers generated high public support for the program. Viewable bulls are now common in many areas where it was previously rare to see a bull after the hunting season.

But there were disadvantages, including (1) an initial reduction in the total number of hunters, and (2) a lower harvest of bulls. Natural mortality rates in bull moose ages 2-6 years of age are relatively low. Consequently, most males protected under the SHS system will mature and ultimately be available for harvest under the 50 inch antler regulation. Population modeling predicted that pre-SHS harvest levels might be achievable 7 years after implementation of SHS. The severe winter of 1989-90 delayed this projected harvest by a year or two. Annual harvest however should approach pre-SHS levels once the age structure of the male segment of the population stabilizes.

The definition of a 50 inch antlered bull also included any bull with 3 tines on a brow palm of an antler. This provision was included by the Board of Game to provide hunters unable to judge 50 inch antlers under field conditions another criterion by which to determine a legal bull. Under the 3 tine definition, about 19% of the bulls with antlers less than 50 inches were legal. If this definition were changed to 4 tines, virtually all bulls with an antler spread less than 50 inches would not be legal for harvest. For instance, only 1 of 49 moose measured at the check stations had an antler spread less than 50 inches and more than 3 tines on either antler.

SHS resulted in a shift in the composition of illegally shot moose. Because hunters had to determine antler architecture, the occurrence of cows mistakenly shot as bulls was substantially reduced. Most illegal kills were mis-identified bulls. The vast majority of these were in the 30-40 inch antler range that were thought to have 3 tines on the brow palm. Many hunters had difficulty determining tines on the brow palm from the first tine on the main palm. By eliminating the tine provision, this illegal harvest might be substantially reduced. There is a high likelihood however, that the illegal kill would just shift to bulls in the 45-49 inch antler spread range, because many hunters have similar difficulty in judging antler spread.

Since there is a positive relationship between antler size and body size (Harmel 1982), removal of inferior, small bodied yearlings makes biological sense. Conversely, larger antlered, more vigorous yearlings are protected under SHS. Rapidly growing large-bodied bulls reach the 50 inch antler category at an earlier age. Under SHS, these animals are likely removed from the population prior to the rut. Selectively targeting large antlered bulls under a 50 inch antler regulation seems counter-productive to good herd management.

Morphological characters in red deer (*Cervus elaphus*)(Hartl *et al.* 1991) and white-tailed deer (*Odocoileus virgininaus*) (Templeton *et al.* 1982), which serve as criteria for selective hunting (antler and body size) show significant association with certain alleles. In a study of red deer, Hartl *et al.* (1991) demonstrated that selective hunting of small-bodied spike-antlered red deer selectively removed that trait from the population. Changes in allele frequency at certain loci were not explained by normal genetic drift, and Hartl *et al.* (1991) concluded that selective hunting led toward a change in allele frequencies. They suggested that certain alleles associated with development of morphological characteristics could be lost as a direct consequence of unregulated hunting pressure. Selective harvesting could be operating on the Kenai moose population in a similar fashion. Moreover, if antler development in moose is genetically linked as in red and white-tailed deer, selectively targeting bull moose with antler spreads exceeding 50 inch or those bulls with 3 tines on the brow palm is counter-productive to good herd management.

MANAGEMENT RECOMMENDATIONS

The following should be considered as an alternative to the current SHS season. Under our proposed SHS system, anybody could hunt spike-fork antlered moose during a regular season. A limited number of permits could be issued for all other bull moose regardless of antler architecture to harvest the surplus of males in excess of the target bull:cow ratio. The special season could be extended into the rut since only a limited number of people could participate. This would add to the quality of the experience since hunters could call bulls. By making any bull legal under the permit system, harvest of bull moose having antler architecture other than spike or fork type would likely be random. Under such a controlled and selective harvesting strategy, general open hunting seasons could be maintained, hunter participation maximized, and recreational opportunity optimized (Child and Aitken 1989, Aitken and Child 1992. Furthermore, if a special permit system were introduced to regulate the harvest of mature bulls, the quality of the hunting experience would be enhanced and harvests increased and sustained over time (Child 1983, Child and Aitken 1989).

ACKNOWLEDGEMENTS

Many people contributed to the work reported in this manuscript and we wish to thank them. We especially wish to thank M. Hedrick of the Kenai National Wildlife Refuge (KNWR) for supporting selective harvest. Without his efforts, the program likely would not have been initiated. We are especially indebted to the personnel of the KNWR for their cooperation in manning the check stations. Special thanks to A. J. Loranger for summarizing the check station data. Thanks also to biologists of ADF&G, D. A. Holdermann and G. G. Del Frate who flew many of the aerial surveys. We thank the staff of the State of Alaska, Fish and Wildlife Protection for their assistance in obtaining our sample of reproductive tracts. Editorial comments were provided by K. B. Schneider, S. R. Peterson, and K. Pitcher. This project was a contribution of Federal Aid in Wildlife Restoration, Project W-23-1, W-23-2, W-23-

3, and W-23-4.

REFERENCES

AITKEN, D. A. and K. N. CHILD. 1992. Relationships between in utero productivity and population structure of moose in central British Columbia: an exploratory analysis. Alces 28:175-186.

BAILEY, T. N. and E. E. BANGS. 1980. Moose calving areas and use on the Kenai National Moose Range, Alaska. Proc. N. Am. Moose Conf. Workshop 16:289-313.

BALLARD, W. B., A. W. FRANZMANN, K. P. TAYLOR, T. SPRAKER, C. C. SCHWARTZ, and R. O. PETERSON. 1979. Comparison of techniques utilized to determine moose calf mortality in Alaska. Proc. North Am. Moose Conf. Workshop 15:362-387.

BISHOP, R. H., and R. A. RAUSCH. 1974. Moose population fluctuations in Alaska, 1950-1972. Naturaliste can. 101:559-593.

BOER, A. H. 1992. Fecundity of North American moose (*Alces alces*): A review. Alces Suppl. 1:1-10.

CHILD, K. N. 1983. Selective harvest of moose in Omineca: some preliminary results. Alces 19:162-177.

______, and D. A. AITKEN. 1989. Selective harvests, hunters and moose in central British Columbia. Alces 25:81-97.

DEL FRATE, G. G., and T. H. SPRAKER. 1991. Moose vehicle interactions and an associated public awareness program on the Kenai Peninsula. Alces 27:1-7.

EDWARDS, R. Y., and R. W. RITCEY. 1958. Reproduction in a moose population. J. Wildl. Manage. 22:261-268.

FRANZMANN, A. W., and C. C. SCHWARTZ. 1985. Moose twinning rates: a possible population condition assessment. J. Wildl. Manage. 49:394-396.

______, and ______. 1986. Black bear predation on moose calves in highly productive versus marginal moose habitats on the Kenai Peninsula, Alaska. Alces 22:139-154.

______, ______, and R. O. PETERSON. 1980. Moose calf mortality in summer on the Kenai Peninsula, Alaska. J. Wildl. Manage. 44:764-768.

HARMEL, D. E. 1982. Effects of genetics on antler quality and body size in white-tailed deer. Pages 339-348, *in* R. D. Brown, ed. Antler Development in Cervidae. Caesar Kleberg Wildlife Research Institute, Kingsville, TX.

HARTL, G. B., G. LANG, F. KLEIN, and R. WILLING. 1991. Relationships between allozymes, heterozygosity and morphological characters in red deer (*Cervus elaphus*), and the influence of selective hunting on allele frequency distribution. Heredity 66:343-350.

LORANGER, A.J., T. N. BAILEY, and W. W. LARNED. 1991. Effects of forest succession after fire in moose wintering habitats on the Kenai Peninsula. Alces 27:100-110.

MARKGREN, G. 1969. Reproduction of moose in Sweden. Viltrevy 6:129-299.

PETERSON, R. O., C. C. SCHWARTZ, and W. B. BALLARD. 1983. Eruption patterns of selected teeth in three North American moose populations. J. Wildl. Manage. 47:884-888.

RAUSCH, R. A. 1965. Moose Report 5 and 6, Proj. W-6-R-5 and W-6-R-6. Alaska Dep. Fish and Game, Fed. Aid in Wildl. Restor. Ann. Rep., Proj. W-6-R-5 and W-6-R-6. 115pp.

______, R. A., J. SOMERVILLE, and R. H. BISHOP. 1974. Moose management in Alaska. Naturaliste can. 101:705-721.

SCHWARTZ, C. C., and A. W. FRANZMANN. 1989. Bears, wolves, moose, and forest succession, some management considerations on the Kenai Peninsula, Alaska. Alces 25:1-10.

______, and K. J. HUNDERTMARK. 1993. Reproductive characteristics of Alaskan moose. J. Wildl. Manage. 57:3 (in press).

SERGEANT, D. E., and D. H. PIMLOTT. 1959. Age determination in moose from sectioned incisor teeth. J. Wildl. Manage. 23:315-321.

SIEGEL, S. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill Kogakusha, Tokyo, 312pp.

SOKAL, R. R., and F. J. ROHLF. 1981. Biometry. Second ed. W. H. Freeman and company, New York, 859pp.

TEMPLETON, J. W., R. M. SHARP, J. WILLIAMS, D. DAVIS, D. HARMEL, B. ARMSTRONG, and S. WARDROUP. 1982. Single dominant major gene effect on the expression of antler point numbers in the white-tailed deer. Page 469, *in* R. D. Brown, ed. Antler development in cervidae. Caesar Kleberg Wildlife Research Institute, Kingsville, TX.

TIMMERMANN, H. R. 1987. Moose harvest strategies in North America. Swedish Wildl. Res. Suppl. 1:565-579.