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Effects of Collection Method on Sex and Age Composition of Black Bear (*Ursus americanus*) Harvest in Oregon

Abstract

We investigated sex and age distribution of 5168 black bears (*Ursus americanus*) harvested or live-trapped in Oregon from 1983 through 1994. Successful hunters were asked to submit a lower premolar tooth along with information on date, management unit, sex of the bear and method of take (i.e., using hounds, bait stations or stalking). In addition, we used capture records and tooth samples of bears snared following complaints of damage or live-trapped in two research studies. Tooth collections of hunter-harvested bears represented 5% to 58% of the annual harvest, as estimated from standard hunter phone surveys. Using data from all years, we compared frequency of sex and age classes according to method of harvest (i.e., hounds, bait, stalking, damage removal or live-trapping). More that 60% of bears harvested were males. Hunting with hounds accounted for >50% of the total harvest. Hunting method affected the proportion of males taken. The median age of bears harvested using hounds was greater than for baiting and stalking. Bears from damage removals and the live-trapped sample were older than those taken by stalking and while using bait stations. Our samples indicate different vulnerabilities of the sexes to different collection methods. Vulnerability ratio coefficients for male bears (compared with females) ranged from 1.46 (bait) to 1.12 (damage removals). We conclude that bear harvest data have a considerable age and sex bias, depending on collection methods used. This is likely to confound estimation of effects of changing harvest strategies, such as the prohibition of certain hunting techniques.

Introduction

The black bear (*Ursus americanus*) is an important big game resource in Oregon. During 1983-1994, an average of 22,015 (SE=1,106) bear tags were purchased annually by hunters, providing more than $220,000 in annual revenue for wildlife management to the Oregon Department of Fish and Wildlife (ODFW). Oregon=s bear populations appear stable and there are growing concerns about bear damage to livestock, timber and agricultural crops since 1983 (D. G. Whittaker, ODFW bear program coordinator, pers. comm.). Bears are hunted for one to two months in the spring on a limited entry license, and for three months during the fall on a general license. Prior to December 1994 bears could legally be harvested using hounds, bait and traditional stalking methods. However, use of hounds and bait was outlawed in December 1994 by voter initiative (Oregon Measure 18, hereafter called measure 18). In addition, special permits are issued to landowners experiencing damage to forest stands, crops or livestock. Because of their secretive habits and forested habitats, black bears are difficult to survey. Population estimation using mark-recapture studies are costly and often do not provide the necessary information in time for management decisions. Consequently, age and sex composition of harvested bears is used by wildlife managers as an index to population status, but the biological interpretation of such information is often not trivial.

In this paper, we present a case study of biases in hunter-harvested samples of large mammal species and the applicability of harvest data as indices for population management. In particular, we were interested in determining if harvest data are sufficiently unbiased to allow inferences about the population=s response to management. Because Measure 18 effectively eliminated the primary methods for harvesting bears, we tested the assumption that different methods do not affect composition of harvest and thus might be a random sample of bear populations statewide. We analyzed age and sex composition of harvested black bears in Oregon since 1983, to (1) compare sex and age composition associated with different collection methods, and (2) to evaluate if these data allow measuring potential impacts to Measure 18 on bear populations.

Methods

From 1983 through 1994 and estimated 14,785 bears were legally harvested in Oregon. Our sample contained 3811 hunter harvested bears for which

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age, sex and harvest method was known. In addition, we used age and sex structure of 1,263 bears taken by Animal Damage Control (ADC) personnel following damage complaints and 94 live-captured bears from two field studies for comparison. Bears inflicting damage to timber stands were primarily snared, while bears involved in livestock depredation were primarily removed using hounds. All bears taken upon damage complaints or live-trapped for research purposes were examined by ODFW biologists or ADC personnel, who extracted teeth and determined sex of bears. Prior to 1987, a volunteer program existed where bear hunters that submitted a harvest report card received a tooth envelope. The hunters were then asked to return the envelope with a premolar tooth and state the sex of the harvested bear and whether they used hounds or not. Beginning in 1987 successful hunters were asked to submit harvest information and a premolar in a special envelope issued with their tag. Before 1987, data contained information only on whether hounds were used or not. After 1987, bears harvested by stalking and hunting over bait were identified. Based on telephone surveys of hunters, 39.3 ± 8.6% of all successful bear hunters submitted a tooth after 1987. Bear teeth were sectioned and aged using the cementum annuli method (Willey 1974) at a commercial laboratory (Matson's Laboratory, Milltown, MT). Samples were sorted by season and collection method (hunted with hounds, hunted over bait, hunted while stalking, hunted without hounds, taken following damage complaints or live-captured for research purposes). We eliminated teeth from analysis if the collection method was not specified.

Because the resolution of collection information changed during our study, we tested for a significant effect of sampling period (i.e., 1983-1986 and 1987-1994, respectively) on age distribution of bears. Sampling period and interactions with collection method and sex did not contribute to model variance ($P > 0.05$), thus all harvest records were pooled. We used a Z-test of binomial proportions (Snedecor and Cochran 1980) to determine if sex ratios (proportion of males in the harvest) differed among collection methods. We used a linear regression of log-transformed frequency data for bears 3-22 years old to estimate instantaneous harvest mortality rates for each method of take (Bunnell and Tait 1980). We calculated the ratio of slope estimates for male and female (β_m/B_f) bears as an index to relative vulnerability of the sexes to different collection methods.

We used analysis of variance to detect effects of hunting/trapping method on age of bears. Because age frequency distributions of harvested bears were left-skewed, we used their median values as a measure of central tendency. We obtained the distribution of median ages for each sex and collection method by drawing 1,000 replications of a bootstrap sample comprising 100 records randomly selected from the original data set (with replacement). The distribution of median ages for each cohort was tested for normality and used a simple one-tailed t-test to test for differences among median ages. We accepted a type-I error rate of 0.05 for all tests.

Results

Bears taken from 1983 through 1994 in Oregon were predominantly male. Sex ratio of bears in damage removals was higher (71.3 ± 0.1% males) than the sex ratio of hunter harvested bears (64.3 ± 0.7% males, $Z = 2.68$, $P < 0.005$). Male bears also dominated the sample of bears live-trapped for research purposes (60.64 ± 0.06%), but there was no difference in the proportion of males compared with the hunted sample ($Z = 0.55$, $P > 0.05$), or damage removals ($Z = 1.71$, $P > 0.05$). Collection method affected the proportion of males taken by bear hunters, those using bait harvested a higher proportion of males than hound hunters (71.90 ± 0.22% vs. 64.09 ± 0.11%, $Z = 2.54$, $P < 0.005$). Bait hunting also resulted in a higher proportion of males than hunting by stalking (71.90 ± 0.22% vs. 61.4 ± 0.22%, $Z = 2.54$, $P < 0.005$). We suspected that spring bear hunters employing stalking would be more selective than stalking hunters in the fall, when bears may be taken incidentally while hunting other big game. However, there was no difference between the proportion of males harvested by stalking in spring (79.5 ± 6.8%) and fall (71.9 ± 2.7%, $Z = 0.96$, $P > 0.05$). Sex ratio of bears harvested with hounds did not differ from those harvested by stalking ($Z = 0.84$, $P < 0.05$).

Method of take and sex of harvested bears were significant factors determining the age of harvested bears ($F_{method} = 7.98$, $P < 0.0001$, $F_{sex} = 18.44$, $P < 0.0001$). Median age was greater for females than for male bears taken after damaging property (4.25

TABLE 1. Means of 1000 bootstrapped median ages of bears taken by different methods, and relative vulnerability coefficients for male black bears to different collection methods in Oregon, 1983-1994. Vulnerability coefficients are calculated for each collection method as the ratio of slope estimates ($\beta_{males}/\beta_{females}$), resulting from linear regression of log-transformed counts (frequencies) over ages of harvested bears.

	Hounds	Bait	Stalking	Damage	Live Capture
			Median Ages:		
Males	4.004 ± 0.004	3.034 ± 0.033	3.006 ± 0.018	3.901 ± 0.010	4.612 ± 0.027
Females	5.192 ± 0.155	3.611 ± 0.254	4.402 ± 0.281	4.250 ± 0.014	5.407 ± 0.021
			Vulnerability Coefficients:		
$\bar{x}$ ± S.D.	1.47 ± 0.31	1.44 ± 0.25	1.12 ± 0.10	1.22 ± 0.13	1.25 ± 0.72

±0.01 vs. 3.90±0.01 years, $t = 20.97$, $P < 0.0001$) and live-trapped bears (5.41 ± 0.02 vs. 4.61 ± 0.03 years, $t = 23.51$, $P < 0.0001$). Differences in median ages between male and female bears removed after damage complaints were lower than for any other method (Table 1). Similarly, median age of bears differed according to sex and hunting method. In general, hound hunters took older bears (male and female) than hunters using bait or stalking (Table 1). When using hounds, hunters killed younger males than females ($t = 94.13$, $P < 0.005$), and males harvested over bait were younger than females ($t = 34.07$, $P < 0.005$). Hunters stalking bears harvested younger males than females ($t = 80.78$, $P < 0.005$), but this tendency was not uniform among spring and fall seasons. In spring, male bears harvested by stalking were older than females ($t = 17.01$, $P < 0.05$) but the sample was small ($n = 44$). Live-trapped bears and those taken by using hounds were the oldest bears in our sample, while those harvested by bait and stalking were younger.

Vulnerability coefficients, based on ratio of instantaneous harvest rates of male and females showed pronounced variation with collection method (Table 1). Vulnerability to harvest was always higher for males than for females. Males appeared most vulnerable to hunters using bait and stalking methods. Hound hunters took relatively larger proportions of females, thus male vulnerability to hound hunters was lowest. Trapping methods such as damage removals and live-capture for research purposes exhibited intermediate vulnerability coefficients.

Discussion

Collection methods employed in Oregon had a significant effect on the sex and age composition of harvested black bear. Harvested black bears contained more male bears than females, and harvested males were younger than females. A heavy male bias in harvested black bears has been reported by other workers (Lindzey and Meslow 1980, Kane and Livaitis 1992, Litvaitis and Kane 1994). This may be due to legal protection afforded to sows with cubs, which may constitute a substantial portion of the female segment of a population. Male black bears in Oregon were significantly more vulnerable to harvest or trapping, and their vulnerability differed among collection methods. Not surprising, sex-specific vulnerability was lowest for hound hunting, where hunters were probably most selective for large bears (Bunnell and Tait 1980, Litvaitis and Kane 1994). However, we found no difference between proportions of males taken by hound hunters (most selective for large bears) and by ADC removals (least selective), and male vulnerability to both methods appeared similar. Similar to our findings, hunters who used stalking methods in New Hampshire (Litvaitis and Kane 1994) harvested lower proportions of male bears and some of the youngest bears, indicating that stalking hunters probably were less selective than hunters who used hounds and hunters using bait. We found that hunters that used stalking methods took older males than females during spring seasons (when bears were the sole species hunted), but the opposite trend was evident during the fall season, where hunters may take bears incidentally while pursuing other game mammals. This difference may be due to differential emergence and movement patterns of the sexes following hibernation. Bait and stalking techniques resulted in the highest proportion of males in the harvest and consequently the highest vulnerability ratio for males. Male home ranges tend to be larger than those of females

(Fraser et al. 1982), hence males should be more likely to encounter bait stations, baited trap sites or stalking hunters. We conclude that the available harvest data does not allow for separation of the effects arising from the legal protection of sows with cubs from those arising from hunter selectivity and bear vulnerability to harvest methods.

If harvest data are to be used as a representative sample of population structure, the sampling process must be random to produce unbiased sex and age structure information. This problem has long been recognized in fisheries management, where selectivity of fishing gear is considered a significant source of bias in stock assessments (Beamesderfer and Rieman 1998). Similarly, the development of capture models with unequal catchability corrections has occupied biologists and statisticians for decades (Pollock et al. 1990). If hunters are selective, or different age classes of animals differ in their vulnerability to harvest, the sampling process is no longer random, and estimates of population statistics are biased. For ungulates, harvest age structure and harvest sex ratio analysis of white-tailed deer (*Odocoileus virginianus*) have been shown to be severely biased due to differential vulnerability of various sex and age classes, and hunter selectivity (Roseberry and Woolf 1991). The pronounced differences in age and sex composition among different sampling methods of bears in Oregon indicated that substantial biases were inherent in hunter-harvested samples, which could affect management decisions. Without harvest-independent samples the true composition of the population cannot be estimated. Alternative methods, such as mark-recapture, are necessary to estimate age and sex-specific survival rates of black bears. Unless sources of bias (hunter preferences, bear behavior toward traps or bait) are known, estimates of population structure derived from harvest statistics appear unreliable. Detection of population responses to change in harvest regimes or hunting methods may be difficult.

We conclude that harvest data of black bear (and many other mammal species) are of questionable value for the assessment of population demography, unless they are confirmed by independent estimates of population composition and growth. We suggest that instead of relying on a single harvest statistic, wildlife managers should attempt to minimize data biases by obtaining precise estimates of total harvest, the harvest effort expended, and the sex-age structure of the harvest. Ancillary data, such as spring body condition indices, reproductive output of females and survival can facilitate the application of population modeling. We urge wildlife managers to consider functional, mechanistic processes of population regulation when making management decisions or assessing population status. Fundamental harvest theory, coupled with computer simulations and sound thinking can provide clues about the population's relative position along a yield curve. Lastly, we strongly recommend that wildlife managers employ adaptive resource management (Walters and Hillborn 1978, Lancia et al. 1996), using controlled harvest of wildlife as a deliberate experimental management action to test hypotheses regarding harvest effects and population regulation. Explicitly testing the effects of management actions can be an effective way of incorporating uncertainty into managing natural resources.

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