A Comparison of Federal and State Duck Harvest Estimates from 1965 to 1975

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Abstract: Estimates of ducks harvested by hunters from 1965 to 1975, as calculated by the U.S. Fish and Wildlife Service, were compared to corresponding estimates calculated by 33 State wildlife agencies. States were grouped into 4 categories according to survey methodology and the relative magnitude of Federal estimates to State estimates was calculated for each category and contrasts performed through analysis of variance on log transformed data. As a group, States where wildlife agencies made pre-season hunter contact produced harvest estimates that were not significantly different from Federal figures. State estimates calculated by the Southeastern Cooperative Fish and Game Statistics Project were significantly higher than Federal estimates, as were estimates from the remaining 2 groups of States where agencies did not make pre-season contact but either sampled or did not sample junior hunters. No statistical evidence was found that inclusion of junior hunters in State surveys affected the relationship between Federal and State estimates.

The United States Fish and Wildlife Service and most State wildlife agencies use hunter surveys to estimate annual waterfowl harvest. Over the years, most State estimates of harvested ducks have consistently been higher than corresponding Federal estimates. Figure 1 illustrates the magnitude of these differences for the State of Georgia.

Our present understanding of the magnitude of biases in waterfowl harvest surveys is based primarily on bag check studies where hunters' bags obtained on well defined public hunting areas were recorded in the field and compared to responses from mail survey questionnaires sent to these same hunters (Atwood 1956; Hayne 1964; Sen 1971, 1972, 1973; Wright 1978). In each of these studies, the survey estimates of waterfowl harvest were larger than actual harvests, sometimes twice the actual value (Wright 1978).
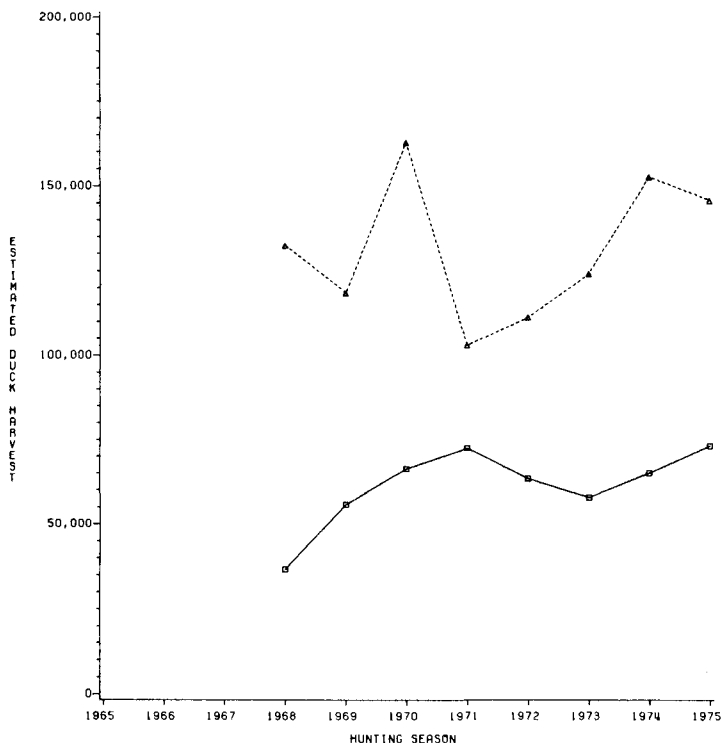
Figure 1.   Number of ducks harvested in Georgia during 1965 to 1975, as estimated by the Georgia State Game and Fish Commission (indicated by △---△) and by the U.S. Fish and Wildlife Service (indicated by □———□); estimates are corrected for suspected survey biases.

Hunters over-reporting their kill consistently accounted for more of the bias than did nonresponse. Hayne (1964), reporting on a bag check study conducted on 9 public hunting areas, found that bias from hunters over-reporting their duck bag ranged from 11 to 57% of the mean of all field records, whereas nonresponse bias plus sampling error ranged between 1.5 and 28%. Incomplete sampling frames were also found to be sources of positive bias. Sen (1972) reported that the use of a previous year sampling frame in the 1969 Canadian National Survey caused an estimated positive bias of 9.9% in waterfowl estimates for Ontario hunters.

Few studies, however, have compared Federal survey estimates with State estimates and none have been presented in the literature. The objectives of this study were to: a) compare Federal and State duck harvest estimates

for 33 States for the 1965 through 1975 hunting seasons, and b) statistically test whether or not observed differences were related to pre-season hunter notification, corrections for nonresponse bias applied by the Southeastern Cooperative Fish and Game Statistics Project, or the inclusion of junior hunters in the sampling frame.

The majority of data for the study were collected by William V. Terry at North Carolina State University. Michael Sorensen of the U.S. Fish and Wildlife Service and many State wildlife biologists throughout the United States were most helpful in responding to inquiries about their respective waterfowl harvest surveys. Additional information on State survey estimates was obtained from the Southeastern Cooperative Fish and Game Statistics Project. Special thanks go to Don W. Hayne for his guidance during the study.

Methods

The original data obtained for the study were annual estimates of ducks harvested in 33 States from 1965 to 1975, as reported by the U.S. Fish and Wildlife Service and by the respective State wildlife agency. Federal estimates were available for each year of the study, but only those with corresponding State estimates were used in the analyses.

Estimates of harvested ducks obtained from the Fish and Wildlife Service were bias adjusted estimates by State-of-kill. These figures contained adjustments for hunters over-reporting their kill and for the exclusion of junior hunters in the Federal sampling frame; the actual adjustment factors, presented by Chamberlain et al. (1971), varied among flyways. An additional reduction factor of 0.9637 was applied by the Fish and Wildlife Service to all harvest figures since 1969 to account for response changes that occurred with an alteration in questionnaire design that year (Sorensen, M. F., Wildlife biologist, Off. of Migratory Bird Manage., Patuxent Wildl. Res. Lab. [Letter to William V. Terry] 27 Apr. 1977).

An attempt was made to calculate Federal estimates that were not adjusted for any suspected biases. This was done by dividing the bias adjusted estimates by the product of all adjustment factors for the appropriate flyway. For those States divided into 2 flyways, the appropriate "unadjustment factor" was applied to each set of estimates; these figures then summed to get the State-of-kill unadjusted Federal estimates used in the analyses.

Many State estimates also reflected an adjustment for hunters over-reporting their kill, the magnitude of this adjustment varying from State to State. Through further correspondence, estimates uncorrected for suspected over-reporting were obtained for all 33 States.

Adjustments for nonresponse bias were also made by several State agen-

Pre-season contact

    yes   no

		yes	no
Tangential correction for nonresponse bias: yes	Sampled junior hunters: yes		Kentucky Maryland
	Sampled junior hunters: no		——— B ——— Alabama Florida Georgia Louisiana Mississippi North Carolina
Tangential correction for nonresponse bias: no	Sampled junior hunters: yes	North Dakota	California New Mexico Idaho New York Iowa(1973-74) Oregon Maine Utah Michigan Washington Missouri C Wyoming Montana Nevada New Jersey
	Sampled junior hunters: no	——— A ——— Kansas Minnesota Oklahoma(1965-67) South Dakota	Alaska Colorado Delaware D Iowa(1965-72,75) Massachusetts Oklahoma(1968-75) Wisconsin

Figure 2. Selected categories (A, B, C, and D) of States based upon similarity in State survey procedures used to estimate the harvest of ducks during 1965 to 1975.

cies. Harvest estimates for Delaware from 1974 to 1975 and for Iowa from 1972 to 1975 were adjusted for nonresponse bias. Estimates for several State agencies which were calculated by the Southeastern Cooperative Fish and Game Statistics Project (SCFGSP) at North Carolina State University were also adjusted for nonresponse bias, but by a tangential correction procedure developed by Chapman et al. (1959). Estimates uncorrected for nonresponse bias were not available for these States.

No other adjustments were made by State agencies. Thus, the State estimates used in the analyses were not adjusted for survey biases except nonresponse bias for some States. All estimates from both Federal and State sources included the bag of hunters during special seasons (e.g. September teal [*Anas* spp.] seasons). However, agencies in Colorado, New York, Oklahoma, and Wyoming included coots (*Fulica americana*) in annual duck harvest figures while Federal estimates for these States reflected only the harvest of ducks. No adjustment was made for this in the analyses.

The first analysis compared Federal and State duck harvest estimates for each State individually. Arithmetic means of Federal and State estimates (i.e. averaged over seasons) were calculated for each State. Paired *t* tests of differences between Federal estimates and those of the respective State wildlife agency were then performed using repeated measures over hunting seasons as replicates. The tests were performed separately for each State and considered independent tests.

States were then grouped according to similar survey procedures as shown in Fig. 2. States where wildlife agencies notified the selected sample of hunters before the season, asked them to keep a record of their kill and told them they would receive a questionnaire at the end of the season, comprised survey category A. The Fish and Wildlife Service also made pre-season contact with the sample of hunters. States where harvest estimates were calculated by the SCFGSP and therefore corrected for nonresponse bias by the tangential correction procedure made up category B. Of the remaining States, those that sampled junior hunters were assigned to category C and those that did not sample junior hunters comprised category D.

Analysis of variance was used to test for differences in the relative magnitude of Federal estimates to State estimates among the 4 survey categories. The model was considered a split plot, the effect of States random within survey category, with repeated measures for each State over years. The dependent variable in the analysis was:

$$r_{ijk} = \log_{10} \left(\frac{\text{Federal estimate}}{\text{State estimate}} \right) \quad \text{for category i, State j, and season k.}$$

The antilog of the arithmetic mean of r_{ijk} for survey category i represented the geometric mean of the relative magnitude of Federal estimates to State estimates for that category. The geometric mean is generally preferred over the arithmetic mean when averaging ratios (Steel and Torrie 1960).

Results

Means of Federal duck harvest estimates ranged from 46% lower to 16% higher than corresponding State means (Table 1) with significant pairwise differences in 17 of the 33 States. Estimates calculated by State agencies in Kansas, Oklahoma, and South Dakota averaged lower than corresponding Federal estimates; Oklahoma's were significantly lower.

Three single degree of freedom contrasts were of particular interest in the analysis of variance (Table 2). For each group in each contrast, the antilog of the least squares mean is presented and tested for significance from unity. This value represents the Federal-to-State relative magnitude for the group after adjusting for other effects in the model. A value of unity indicates

Table 1. Mean Federal and State Duck Harvest Estimates for Years when State Data Were Available between 1965 and 1975

State	Hunting Seasons	Mean Federal Estimate	Mean State Estimate	Significance of Pairwise Differences[a]
Alabama[b]	1965,66,69,71–75	90,539	151,662	**
Alaska	1971–75	91,144	99,881	ns
California	1965–75	2,367,797	3,122,336	**
Colorado[c]	1965–75	206,153	212,061	ns
Delaware[d]	1971–74	54,177	76,990	*
Florida[b]	1970–75	269,358	471,050	**
Georgia[b]	1968–75	70,440	131,067	**
Idaho	1965–75	353,953	534,318	**
Iowa[e]	1965–75	342,850	492,971	**
Kansas	1965–75	381,237	338,254	ns
Kentucky[b]	1965–75	49,588	54,703	ns
Louisiana[b]	1968–73,75	1,618,950	1,973,039	*
Maine	1965–75	97,350	156,766	**
Maryland[b]	1968–75	146,974	160,309	ns
Massachusetts	1966,68,70,75	98,593	131,968	ns
Michigan	1965–75	426,169	488,206	ns
Minnesota	1965–75	1,111,437	1,219,000	**
Mississippi[b]	1970–73	220,103	283,717	ns
Missouri	1967–75	298,132	358,419	**
Montana	1965–75	201,954	205,186	ns
Nevada	1965–75	124,643	133,509	ns
New Jersey	1965–75	144,538	183,842	ns
New Mexico	1965–75	44,958	49,847	ns
New York[c]	1965–69	272,356	294,765	ns
North Carolina[b]	1966,70,72,74	151,106	268,759	ns
North Dakota	1965–75	448,348	602,391	**
Oklahoma[c]	1965–75	233,239	200,191	*
Oregon	1965–75	448,942	528,397	**
South Dakota	1965–75	334,250	308,409	ns
Utah	1965–75	372,286	459,974	**
Washington	1965–75	653,528	963,768	**
Wisconsin	1965–68,71–75	702,989	854,804	**
Wyoming[c]	1965–75	52,507	58,436	ns

[a] Significance is determined by paired t test of Federal and State estimates, using repeated measures over seasons as replicates. ns indicates $P > 0.05$, * indicates $0.01 < P \leq 0.05$, ** indicates $P \leq 0.01$.
[b] State estimates are corrected for nonresponse each year.
[c] State estimates include coots.
[d] State estimates are corrected for nonresponse bias from 1974 to 1975.
[e] State estimates are corrected for nonresponse bias from 1972 to 1975.

no difference between Federal and State estimates. A value less than unity indicates Federal estimates were smaller than State estimates.

The first contrast compared the relative magnitude for State wildlife agencies that made pre-season contact to the relative magnitude for those that did not (A versus B,C,D in Fig. 2). The relative magnitude of 0.9642 for

Table 2. Comparison of the Federal-to-State Relative Magnitude among Survey Categories[a]; Tests of Statistical Significance[b] Constructed through Analysis of Variance on Log-Transformed Data

Contrast	df	Relative Magnitude[c]		Mean Square	F
		Group 1	Group 2		
Survey category	3			0.0991	2.06ns
A vs. B,C,D	1	0.9642ns	0.8195##	0.2203	4.57**
B vs. C,D	1	0.7660##	0.8477##	0.0953	1.98ns
C vs. D	1	0.8238##	0.8723 #	0.0094	0.19ns
State (Survey category)	31			0.0482	
Year	10			0.0329	3.60**
Survey category x year	30			0.0209	2.28**
(A vs. B,C,D) x year	10			0.0120	1.31ns
(B vs. C,D) x year	10			0.0426	4.67**
(C vs. D) x year	10			0.0140	1.53ns
Residual	226			0.0091	

[a] Survey categories: (A) States where wildlife agencies made pre-season contact, (B) States where estimates were calculated by the Southeastern Cooperative Fish and Game Statistics Project and thus corrected for nonresponse bias, (C) States not in A or B, but where wildlife agencies sampled junior hunters, and (D) States not in A or B, but where wildlife agencies did not sample junior hunters.
[b] Significance of contrast indicated by *, whether relative magnitude was significantly less than unity by #, as follows: ns indicates $P > 0.05$, *# indicates $0.01 < P \leq 0.05$, and **## indicates $P \leq 0.01$.
[c] Represents the geometric mean of the relative magnitude of Federal estimates to State estimates and is calculated as the antilog of the least squares mean for the group.

States in group A was not significantly different from unity. The relative magnitude for States whose wildlife agencies did not make pre-season contact (States in B,C, or D) was 0.8195, which was significantly less than unity, and significantly less than the relative magnitude for States that did make pre-season contact.

The second contrast was between States, excluding those in A, where estimates were produced by the SCFGSP and those that were not (B versus C,D in Fig. 2). Estimates for States in category B were corrected for nonresponse bias by the SCFGSP and the Federal-to-State relative magnitude for these States was 0.7660 which was significantly less than unity but not significantly different from the relative magnitude of 0.8477 obtained for States in groups C or D; however, the significance of interaction between this contrast and years indicated the contrast was not consistent over all hunting seasons.

The final contrast was between States in category C, that sampled junior hunters and States in category D, that did not. The relative magnitudes for both groups, 0.8238 for group C and 0.8723 for group D, were significantly less than unity, but these values were not significantly different from each other.

Discussion

Biases in survey estimates arise from 3 general types of errors: (a) incorrect or incomplete sampling frames, (b) nonresponse, and (c) misreporting by respondents. Consistent differences between Federal and States estimates result from the differential success of these surveys in eliminating such biases. Consistent differences were observed in this study, but there was no evidence concerning which figures were closer to actual harvests. Here I wish only to discuss possible reasons for the consistent differences observed between Federal and State estimates.

The wildlife agencies of 5 States—North Dakota, South Dakota, Minnesota, Kansas, and Oklahoma—made pre-season hunter contact during the 11 years of the study (only from 1965 to 1967 in Oklahoma). In addition to a cover letter informing the hunter he would be sent a questionnaire at the season's end, most of these State agencies also provided the hunter a diary and asked him to keep track of the game he, as an individual, harvested during the season.

The Fish and Wildlife Service also made pre-season contact, but in a different manner. Each post office selected to be a sample outlet in the survey was sent contact cards that were to be given to persons purchasing Federal duck stamps at that location. Each card requested the purchaser to fill in his name and address and return this portion to the postal clerk for mailing to the Fish and Wildlife Service. Only those persons returning the name and address form were included in the Federal sampling frame. The contact card informed the hunter he would receive a questionnaire at the end of the season and a detachable diary was provided so he could record his kill as the season progressed (Couling et al. 1982).

The first contrast in Table 2 indicated that when both Federal and State agencies made such a pre-season contact, their estimates were not significantly different. When State agencies did not make pre-season contact, their estimates were significantly higher than Federal figures. Either pre-season notification reduced duck estimates in both Federal and State surveys or something confounded with State pre-season notification reduced duck estimates in State surveys.

If pre-season notification did, in fact, reduce estimates in both surveys then that reduction was probably achieved by decreasing memory bias as defined by Atwood (1956). Over-reporting has consistently been the largest source of positive bias in bag check studies, and similar in magnitude to the differences observed in this study between Federal and State estimates when State agencies did not make pre-season contact.

Pre-season notification was confounded in the present study with other survey procedures. Four of the 5 State agencies that made pre-season con-

tact also sampled from previous-year license files. It may be that harvest estimates from these State agencies were similar to Federal figures because previous-year frames caused a downward bias in harvest estimates. Sen (1971 and 1972) has reported, however, that previous-year frames tend to exclude unsteady hunters and therefore result in an upward bias of harvest estimates.

There were also 4 State agencies in the present study—Florida, Maine, Louisiana, and Wisconsin—that used previous year frames but did not make pre-season contact. For each State, the mean Federal duck harvest estimate was significantly less than the mean State estimate, ranging from 18 to 43% less (Table 1). So, the use of previous-year sampling frames did not necessarily result in duck harvest estimates similar in magnitude to Federal estimates.

On the other hand, the mean Federal duck harvest estimate for North Dakota was 26% lower than the State mean (Table 1) even though North Dakota's State game agency made pre-season hunter contact. This may have resulted because State estimates were extrapolated to the entire universe of adult and junior hunters whereas Federal estimates included only adult hunter activity. This contradicts, however, the finding that State estimates which included the harvest of junior hunters were not, as a group, significantly closer to Federal estimates than State estimates that did not include junior hunter activity (Table 2). Perhaps junior hunters were more important in North Dakota than in some other States. Another consideration is that the contrast in Table 2 between categories C and D may have lacked sufficient power to detect a real difference because of the large variability among States within each category. In any case, the effect of junior hunters on the relationship between Federal and State estimates was inconclusive.

The method used by the Fish and Wildlife Service to construct a current year sampling frame was a potential source of bias in Federal survey estimates that did not exist in State estimates. Couling et al. (1982) reported that in an investigation of 12 States during 1971 and 1972, >50% of the persons buying duck stamps at sample outlets failed to return a name and address form and were therefore excluded from the sampling frame. This suggests that Federal estimates in the present study could have been biased if hunters not included in the frame averaged a seasonal duck bag different from those that were included. Unfortunately, the probable direction of such a bias was unknown. Even if it reduced Federal estimates, it would not explain why Federal and State figures were similar for States where agencies made pre-season contact.

Estimates calculated by the SCFGSP, as a group, exhibited a relative magnitude with Federal figures similar to that exhibited by other States where pre-season hunter contact was not made. The contrast of these 2 groups (B versus C,D), however, was not consistent over years. This in itself may be a

reasonable result because duck estimates calculated by the SCFGSP were corrected for nonresponse bias by a tangential correction procedure in which the actual adjustment changed from year to year dependent on the pattern of response over 3 mailings for each year's sample of hunters (Chapman et al. 1959). If this correction was large in some years and not in others, then the Federal-to-State relative magnitude for these States should also have varied.

In summary, Federal duck harvest estimates uncorrected for suspected survey biases averaged significantly lower than corresponding estimates for a majority of States from 1965 to 1975. Neither the inclusion of junior hunters in some State surveys nor the correction for nonresponse bias applied by the Southeastern Cooperative Fish and Game Statistics Project seemed to explain the observed discrepancies between Federal and State estimates. Pre-season hunter notification did appear important. When both Federal and State agencies made pre-season contact, their estimates were not significantly different. Pre-season notification may have reduced the suspected bias of hunters over-reporting their kill.

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