Evaluation of a Sampling Design Used to Estimate Waterfowl Abundance on Catfish Ponds

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Abstract: A stratified random survey design proposed to increase the efficiency of estimating numbers of waterfowl wintering on Mississippi catfish ponds was evaluated. The optimally allocated sample generally produced estimates with coefficients of variation <50%, similar to those obtained from a completely random design used previously. Coefficients of variation were not associated with survey date. Stratified random sampling reduced the number of catfish pond clusters surveyed and flight time, compared to completely random sampling. We recommend using the stratified random design to estimate numbers of waterfowl on aquacultural impoundments when sampling of impoundments must be limited.

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Catfish (primarily *Ictalurus punctatus*) farming is an important industry in the southeastern United States. Mississippi, Alabama, Arkansas, and Georgia contained approximately 43,300 ha of catfish ponds in 1985 (Wellborn 1986 cited by Rosenberry 1986). Catfish ponds in Mississippi attract many migrating and wintering waterfowl annually (Christopher 1985; Dubovsky 1987; Dubovsky and Kaminski 1987 *a,b;* Christopher et al. 1988). For winters 1983–84 through 1986–87, Dubovsky and Kaminski (1987*b*) reported averages of 54,000–121,000 waterfowl (i.e., ducks, geese, and American coots [*Fulica americana*]) using catfish ponds in Mississippi, which had >33,000 ha of ponds (Wellborn et al. 1986).

Christopher (1985) and Dubovsky (1987) estimated waterfowl abundance on Mississippi catfish ponds using aerial surveys with a completely random sampling design. Christopher et al. (1986) proposed using a stratified random sampling design to reduce the number of catfish farms surveyed without sacrificing precision of estimates of waterfowl. They recommended stratifying the study area into geographic strata based on densities of catfish ponds in the study area, and concentrating survey efforts in areas of highest pond densities. However, the stratified random design was based on data Christopher (1985) collected, and thus had not been evaluated using data collected after its implementation. Therefore, our objective was to evaluate stratified random sampling as a replacement for the completely random design.

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Study Area

Catfish-pond clusters (i.e., groups of contiguous catfish ponds separated from other such groups by a distance greater than or equal to the width of a 2-lane roadway) were surveyed for waterfowl in Bolivar, Holmes, Humphreys, LeFlore, Sharkey, Sunflower, and Washington counties in west-central Mississippi. These counties contained approximately 94% of the catfish-pond acreage in Mississippi in 1986 (Wellborn et al. 1986). Pond clusters ranged from 20–850 ha, and were typically comprised of contiguous 8-ha ponds, 1–2 m deep (Christopher 1985). Humphreys and Sunflower counties contained approximately 46% and 25% of the catfish ponds, respectively; the other 5 counties averaged 6% each (Christopher et al. 1986).

Methods

Clusters were located on a LANDSAT image and their locations transferred to Mississippi county maps (Christopher 1985, Dubovsky 1987). Christopher et al. (1986) recommended that the surveys be divided into the following strata: (1) clusters in Humphreys County, and (2) clusters in other counties. For each survey, Christopher et al. (1986) suggested a sample of 57 clusters (37 from Humphreys County and 20 from the other 6 counties) to obtain estimates of total waterfowl abundance with associated coefficients of variation (CV) of ≤40%. Clusters were selected randomly and surveyed aerially for waterfowl approximately every other week from 9 November 1986 to 17 February 1987, and from 29 November 1987 to 16 January

1988. Surveys were conducted using a Cessna 172 fixed-wing aircraft. When approaching a cluster, the aircraft was slowed to a speed of approximately 100 km/hour and lowered to an altitude of approximately 65 m. A species-specific estimate of waterfowl abundance was tape recorded. For clusters harboring large concentrations of waterfowl, successive passes at a lower altitude (approximately 30 m) were performed to ensure estimation of the number of birds present. Birds seldom flushed during low passes. When they did, their movement to a new location within the cluster was noted to minimize duplicating counts of waterfowl.

Estimates of species-specific and total waterfowl abundance and associated CV's were calculated for each survey. Species-specific and total waterfowl abundance were calculated using a stratified random sampling formula (Cochran 1977:270). Spearman-rank correlation analysis was used to test for an association between CV's and the Julian date of surveys.

Results

Estimates of total waterfowl abundance on catfish ponds ranged from 35,805 (CV = 38%) to 147,113 (CV = 30%) birds during winter 1986–87, and from 93,225 (CV = 25%) to 134,340 (CV = 33%) birds during winter 1987–88. Northern shovelers (*Anas clypeata*), ruddy ducks (*Oxyura jamaicensis*), scaup (*Aythya affinis, A. marila*), and American coots comprised 93% and 84% of all waterfowl on catfish ponds during winters 1986–87 and 1987–88, respectively. Because these 4 species comprised the majority of waterfowl inhabiting catfish ponds during this and previous studies (Christopher 1985, Dubovsky 1987), subsequent results and discussion will be confined to these species and total waterfowl abundance.

Coefficients of variation for total waterfowl abundance ranged from 20% to 38% during winter 1986–87, and from 20% to 33% during winter 1987–88; however, CV's for individual species were generally larger, ranging from 23% to 68% (Table 1). Coot estimates usually had higher CV's than the other 3 species, and equalled or exceeded 50% in 8 of 11 surveys. In contrast, CV's for the other species exceeded 50% in only 3 of 33 cases. The 3 instances in which CV's were >50% for ruddy ducks and scaup occurred during the first survey of each winter.

In general, CV's were not associated with Julian date of surveys. Only for total waterfowl in 1986–87 was there a correlation (Table 2).

Discussion

The stratified random design produced estimates of total waterfowl abundance with CV's of ≤40%, similar in magnitude to those obtained from the larger, completely random design. The completely random sampling design yielded estimates of total waterfowl abundance with CV's ranging between 20%–36% (*N* = 92 clusters surveyed), 13%–33% (*N* = 115 clusters surveyed), and 14%–37% (*N* = 99 clusters surveyed) for surveys conducted during 1983–84 (*N* = 19 surveys), 1984–85 (*N* = 11 surveys), and 1985–86 (*N* = 12 surveys), respectively (Christopher

Table 1. Coefficients of variation (%) for estimates of waterfowl on catfish ponds ($N = 57$) in Mississippi during winters 1986–87 and 1987–88.

Date	Total waterfowl	Northern shoveler	Ruddy duck	Scaup	American coot
09 Nov 1986	38	44	68	54	50
06 Dec 1986	26	42	30	32	49
21 Dec 1986	30	49	32	32	57
03 Jan 1987	30	47	26	35	62
28 Jan 1987	25	36	29	34	53
17 Feb 1987	20	23	31	27	47
29 Nov 1987	25	34	51	27	54
08 Dec 1987	24	38	33	25	50
23 Dec 1987	20	27	30	25	57
05 Jan 1988	21	27	39	35	65
16 Jan 1988	33	44	44	28	34

1985, Dubovsky 1987). The stratified random design successfully reduced sampling effort ($N = 57$ clusters surveyed) without decreasing precision of total waterfowl estimates.

Christopher et al. (1986) stated that the maximum acceptable CV's for estimates of total waterfowl abundance on Mississippi catfish ponds might be between 40% to 50%, and that individual species estimates with CV's >40% were not reliable. The maximum acceptable CV will vary among studies based on the level of precision desired. We used a 40% level only because that was the level Christopher et al. (1986) deemed acceptable, and then used that level as a basis for comparison. Christopher et al. (1986) reported strata sizes and strata-specific variances associated with waterfowl estimates. Theoretically, an investigator could calculate from those numbers a sample size to achieve any desired level of precision.

Using the stratified random design, CV's for total waterfowl were below arbitrary maximum values suggested by Christopher et al. (1986). In 30 of 33 instances, CV's for northern shovelers, ruddy ducks, and scaup were <50%. However, esti-

Table 2. Spearman-rank correlation coefficients (r) and associated probabilities (P) between coefficients of variation for estimates of waterfowl on Mississippi catfish farms and Julian date the survey was conducted.

Species	Winter 1986–87		Winter 1987–88	
	r	P	r	P
Northern shoveler	−0.54	0.13	0.20	0.37
Ruddy duck	−0.49	0.16	−0.10	0.44
Scaup	−0.52	0.14	0.60	0.14
American coot	−0.09	0.44	−0.10	0.44
Total waterfowl	−0.83	0.02	0.10	0.44

mates of American coots may not be reliable, because CV's were ≥50% for 8 of 11 surveys. Coefficients of variation for the other species exceeded 50% only during the first survey of each winter, when numbers of waterfowl on catfish ponds were comparatively low. We conclude that the stratified random sampling design produced estimates with levels of precision comparable to levels achieved with the completely random design for total waterfowl abundance and the common duck species.

The reduction in farms surveyed (from about 100 to 57) resulted in a reduction of about 1–2 hours of flight time per survey (i.e., from 6–7 hours to 5–6 hours). Reduction in flight time (14%–17%) did not equal the reduction in sampling effort (43%) because the same amount of survey area had to be traversed regardless of the design used. Decreased flight time also reduced observer fatigue, possibly resulting in more reliable identification of waterfowl and estimation of waterfowl abundance due to increased observer alertness (Diem and Lu 1960).

Generally, CV's were not related to dates of aerial surveys. Thus, we predict that CV's will not decline as winter progresses.

We recommend that an optimal allocation, stratified random survey design be used to estimate waterfowl abundance on catfish ponds in Mississippi, and possibly aquacultural impoundments elsewhere. Christopher et al. (1986) found that completely random sampling of 20%–40% of the sampling universe can result in estimates of waterfowl with associated CV's of ≤40%. Therefore, the stratified random design may be appropriate when the sampling universe is large and sampling of 20%–40% of the impoundments is cost or time prohibitive. However, completely random sampling may be appropriate when the sampling universe is small.

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