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Use of Surface Visual Counts for Estimating Relative Abundance of Age-0 Paddlefish in Lake Sakakawea

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Abstract.—We describe a method for assessing relative reproductive success and year-class strength of paddlefish *Polyodon spathula* in reservoirs based on visual surface counts of age-0 fish in late summer and early fall. In 1992 and 1993, we visually counted age-0 paddlefish and trawled the surface over a series of transects in upper Lake Sakakawea, a Missouri River main-stem reservoir in North Dakota. The visual counts were strongly correlated with the trawl catches. Compared with trawling, counts provided less variability in year-class estimates, required less personnel and equipment, and avoided handling mortality. Surface counts could be useful for assessing relative year-class strength of paddlefish in areas where significant numbers and densities of age-0 paddlefish exist.

Assessment of the reproductive success and status of a fish stock often involves a means of quantitatively assessing either the absolute or relative year-class strength of juveniles (e.g., Beckman and Elrod 1971; Harper and Namminga 1986). For the paddlefish *Polyodon spathula,* no standard method exists for quantitative assessment of juvenile fish, although trawling has been effective for sampling age-0 fish in some reservoirs. Ruelle and Hudson (1977) used a trawl to capture age-0 paddlefish near the bottom (10–12-m depths) of Lewis and Clark Lake, a Missouri River reservoir in Nebraska and South Dakota, and Pasch et al. (1980) used an epibenthic sled that functioned as a bottom trawl to sample age-0 paddlefish in Old Hickory Reservoir, Tennessee. Biologists from the North Dakota Game and Fish Department (NDGFD) towed a shrimp trawl near the surface to capture age-0 paddlefish in upper Lake Sakakawea (J. Hendrickson, NDGFD, personal communication).

Although visual counts (hereafter referred to as counts) of free-ranging fish have not been used for assessing year-class strength of paddlefish, they have been used effectively for other species. Northcote and Wilkie (1963) evaluated the use of underwater counts for salmonid fishes and concluded that counts could be used to obtain reliable estimates of fish abundance in habitats where other methods were ineffective. Hankin and Reeves (1988) demonstrated that visual estimation can provide a cost-effective alternative to more traditional methods. Counts from streambanks (Cartwright 1961; Irvine et al. 1992) and from aircraft (Bevan 1961) of live fish and carcasses have been used to estimate numbers of spawning salmonids. Counts have also been used for many years in marine environments, particularly in quantifying absolute and relative abundances of coral reef fishes (Brock 1954; Sale and Douglas 1981). These methods, which generally involve divers counting fish as they swim along transects, have been extensively evaluated (Brock 1982; Thresher and Gunn 1986), and models have been developed to account for biases (Quinn and Gallucci 1980; Sale and Douglas 1981).

Our objective in this study was to evaluate the feasibility of counting age-0 paddlefish along transects in a large reservoir and to determine if counts could be useful in assessing year-class strength of this particular stock.

Study Area

The study was conducted on Lake Sakakawea, a main-stem impoundment of the Missouri River. At full pool, the reservoir covers 149,000 ha and is 270 km long. The reservoir supports one of only a few self-sustaining, harvestable paddlefish populations remaining in the United States. Adult paddlefish spawn in the Yellowstone River and in the Missouri River (Rehwinkel 1978) during the high flows of late spring and early summer. After hatching, age-0 paddlefish move downriver into Lake Sakakawea, where they remain for several years (8–10 for males, 15–18 for females; Scarnecchia et al. 1996) before becoming sexually mature.

Sampling of age-0 paddlefish was concentrated in the inflow area of the reservoir between river kilometer (rkm, from the confluence with the Mississippi River) 2,428 and rkm 2,458 (Figure 1). Within this 30 km section, Lake Sakakawea ranged from 1 to 4 km wide. In 1992, the area had depths of 0.5–4 m and was highly turbid (Secchi depth,

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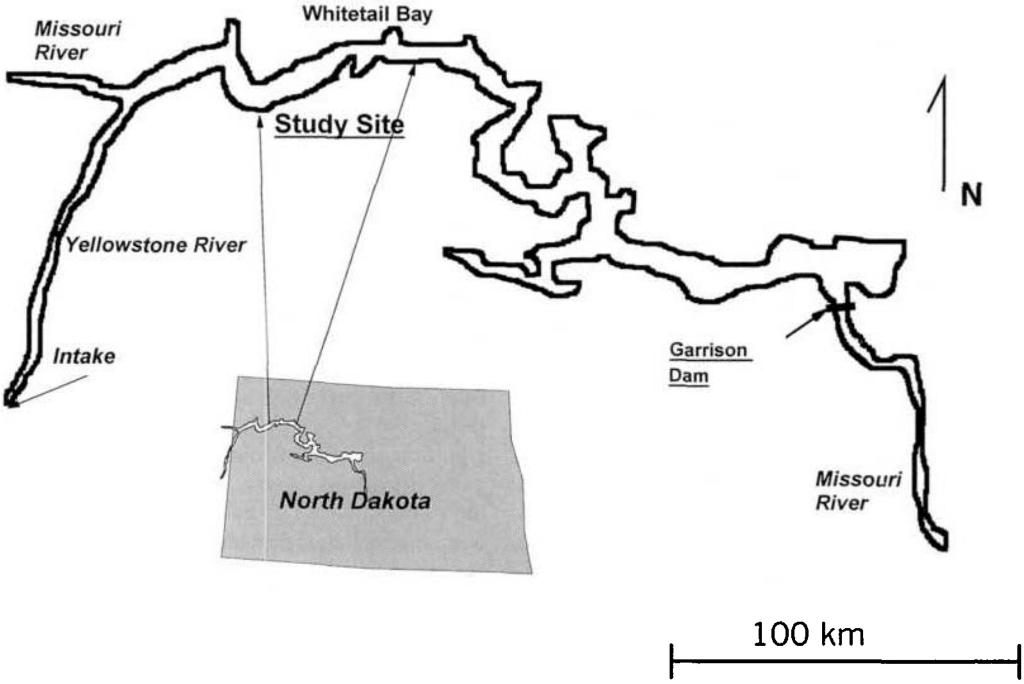

FIGURE 1.—Location of the study site, which encompassed the inflow area of Lake Sakakawea, North Dakota, where visual counts and trawls for paddlefish were made.

0–30 cm). In 1993, regional precipitation and high flows resulted in a substantially higher pool elevation than in 1992 (559 and 556 m above mean sea level, respectively). The range of depths increased to 3–7 m, and water transparency increased (Secchi depth, 13–50 cm). The increased depth in 1993 enabled us to navigate further up the reservoir and expand our study area from 1992. By doing so, we continued to encompass the transitional area from a river to reservoir environment.

Methods

We established a series of sampling sites to encompass the range of habitats in the inflow area of the reservoir. We then established three parallel 1.6-km transects at each site to obtain estimates of variability of the counts. We used a long range navigation (loran) system to create fixed endpoints of the transects for accurate duplication. The loran system also enabled us to monitor and maintain a boat speed of 8.0–9.5 km/h during counts. Paddlefish were counted along each transect by two observers, one near the bow and one near the stern of the boat. Each observer was responsible for one side of the boat, and the paddlefish were counted out loud to ensure that each was not counted more than once. Only fish within an estimated 10 m of either side of the boat were counted. Classification of paddlefish as age-0 was based on length, which was also estimated visually.

Six sites were sampled in 1992 and nine in 1993; the higher water levels in 1993 allowed the addition of three sites in areas that were too shallow to sample in 1992. In 1992, we sampled each site twice per calendar week from August 16 to September 2, once in the morning (0700–1200 hours) and once in the afternoon (1400–1900 hours). Because of equipment failure, we sampled the stations only once during the final week of 1992 (September 6–10). In 1993, we sampled each site on alternate calendar weeks from July 12 to September 24. As in 1992, each site was sampled twice per week, once in the morning and once in the afternoon. The uppermost sites were generally characterized by higher water velocities (0.3–1 m/s), lower Secchi transparencies (<10 cm), and lower zooplankton densities (<5 organisms/L). The lowermost sites were generally characterized by negligible water velocities, higher Secchi transparencies (>30 cm), and higher zooplankton densities (150 organisms/L).

Immediately after conducting counts at a site, we trawled with a 7.6-m (headrope) shrimp trawl

(12.5-mm mesh; 1.5-mm cod-end insert). Because the woody debris and shallow water resulted in frequent hang-ups when trawling near the bottom, the trawl was pulled between two boats on the surface at speeds of 7–9 km/h. To ensure a wide opening to the trawl, two 4-kg weights were secured to the weighted line of the trawl, and the headrope was equipped with plastic floats to keep the trawl on the surface. Three 5-min tows were conducted at each site. In 1993, we trawled each time a station was sampled. Because of breakdowns during the 1992 field season, we trawled each site only for two sampling weeks (August 22–27 and August 29–September 3).

We used Spearman's correlation analysis to assess the association between count and trawl catches. For each site, all three transect counts and trawl catches were summed for analysis. Mean and standard deviations were estimated for each of the counts and trawls at each station, and the coefficient of variation (CV = SD/mean) was used to identify the most consistent index of abundance. For the CV analysis, we used only those samples in which at least one paddlefish was counted and trawled at a sampling site, thereby avoiding the low CV caused by zero paddlefish counts or trawls. We used a Wilcoxon signed-ranks test to assess the difference between the morning and afternoon counts.

Results

Counts

We counted 220 age-0 paddlefish in 1992 and 1,551 in 1993. In 1992, the mean count at a single site ranged from 0.0 to 10.3 fish/transect. During the week of highest counts (August 16–21), 109 age-0 paddlefish were counted over the 36 transects, for a mean of 3 fish/transect. Mean counts in 1993 ranged from 0.0 to 36.7 fish/transect. During the week of highest counts in 1993 (August 23–28), 769 age-0 paddlefish were counted over the 54 transects for a mean of 14.2 fish/transect. In both 1992 and 1993, CV values ranged from 0.0 to 1.8. We found no significant difference in counts of age-0 fish between the morning and afternoon counts in either 1992 ($P = 0.3$) or 1993 ($P = 0.09$).

Trawling

We captured age-0, age-1, and older paddlefish in the trawl, ranging in body length (BL, front of eye to fork of caudal fin; Ruelle and Hudson 1977) from 69 to 785 mm. Overall, trawling was more successful in 1993 than in 1992. The 1992 trawling effort ($N = 72$) yielded 14 age-0 paddlefish, or 0.2/tow. The highest total catch during three tows at a single station was three paddlefish. In 1993, during the sampling periods when age-0 paddlefish were present, 216 tows yielded 93 age-0 paddlefish, or 0.4/tow. The highest catch in three tows at a single station was nine paddlefish. As with counts, CV values ranged from 0.0 to 1.8 in both 1992 and 1993.

Comparison between Visual Counts and Trawling

Combined data from 1992 and 1993 indicated that age-0 counts and trawl catch at the same station were strongly and positively correlated (Spearman's $r_s = 0.72$, $P < 0.01$). Counts had significantly lower CV values (Wilcoxon matched-pairs signed-ranks test, $P < 0.01$, df = 32) than did trawl catches for those sample sites where fish were counted and trawled. In only three cases did the trawl have equal or lesser CV values than the counts. In both years, we were able to enumerate far more fish by counting than by trawling. In 1992, using hours as units in a catch-per-effort comparison, we were able to count an average of 10.4 age-0 fish/h and only trawled 2.2/h. In 1993, we counted 43 age-0 fish/h and trawled 5.2/h.

Discussion

We believe counts can be used as an effective index of year-class strength for paddlefish. Two points suggest that differences in counts between 1992 and 1993 reflect true differences in population abundance at the study site. First, spawning activity, as estimated by harvest of spawning paddlefish in 1992 and 1993, was consistent with trends in subsequent numbers of age-0 paddlefish counted. Paddlefish are harvested during spawning runs into the Yellowstone River, largely from a short reach of river at Intake, Montana. Harvest varied considerably between 1992 and 1993. Only 740 paddlefish were harvested in 1992 (0.09 fish/h), making it one of the lowest harvests on record (Stewart 1993), whereas 1,635 paddlefish (0.13 fish/h; Stewart 1994) were harvested in 1993. We believe low harvest rates were associated with a low number of spawning paddlefish and conclude that 1992 was a weak spawning year in comparison with 1993. Coincidentally, counts and trawls both resulted in fewer age-0 paddlefish in 1992 than in 1993. Second, the positive correlation between the number counted and number trawled supports the quantitative merit of both methods. Although to our knowledge trawling has not been established as a quantitative sampling method for juvenile paddlefish, it is an accepted method for assessing relative year-class strength of many fish populations.

Counts were preferable to trawls both in terms of expense and information gained. We were frequently able to count paddlefish in areas where trawling was unsuccessful. Analysis of CVs demonstrated that information gained from counting was less variable than that gained by trawling, suggesting the need for fewer samples. In addition to the ability of counts to provide a greater amount of information in a given period of time, counts can be advantageous for other reasons. Counting fish without netting, shocking, trapping, or handling them has great appeal because of the absence of handling mortality. Trawl tows, in contrast, must be brief because age-0 paddlefish are easily stressed, particularly when the water temperature exceeds 21°C (Graham et al. 1986). In our study, many age-0 paddlefish caught by the trawl were slow to revive, even with short tows. Trawling in upper Lake Sakakawea required two boats, preferably with a total of three people. The added fuel, equipment maintenance, and personnel significantly increase the expense of the efforts.

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