Gill Net Selectivity and Size Structure in White Bass

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Abstract: I used a normal-skew model to calculate length-specific selection curves for white bass caught in gill nets in 55 Texas reservoirs. I used these selection curves to adjust 2 size-structure indices, proportional stock density (PSD), and relative stock density (RSD) for gill net mesh-size selectivity. Differences between adjusted and unadjusted values of PSD and RSD were small (0.6 and 2.0, respectively) when the unadjusted values were extreme (i.e., ≤10 or ≥91). When unadjusted values of PSD and RSD were between 10 and 91, mean absolute differences between adjusted and unadjusted values were 5.6 and 6.7, respectively. There were no obvious patterns to the differences between adjusted and unadjusted values of PSD and RSD.

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White bass (*Morone chrysops*) is widely distributed in Texas rivers and reservoirs. Although the fishery is seasonal with most angler effort concentrated in spring, white bass is the fifth most actively pursued sport fish in Texas fresh waters; during 1989, white bass received 4.5% of directed angler effort and accounted for 9.9% by weight of all freshwater fish harvested by anglers. Texas Parks and Wildlife Department (TPWD) uses gill nets to monitor trends in abundance and size structure of white bass populations. However, detection and interpretation of trends, especially in size structure, are complicated by size selectivity of gill nets (Hamley 1975).

Several methods have been developed to adjust size-structure data for gill net selectivity (Gulland and Harding 1961, Regier and Robson 1966, Willis et al. 1985, Kirkwood and Walker 1986, Ehrhardt and Die 1988). Willis et al. (1985) reported significant differences between adjusted and unadjusted values for 2 size-structure indices for white bass. Although the method used by Willis et al. (1985) makes several assumptions which are untenable for white bass stocks in Texas, their results suggest a need to adjust length-frequency distributions and size-structure indices for gill net selectivity. My purposes in this paper are to: 1) describe gill net mesh-size selectivity for white bass, and 2) assess the effects of mesh selectivity on size-structure indices for white bass.

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Methods

White bass were collected from 55 Texas reservoirs in the course of routine gill net sampling during 1984 to 1991. Gill nets were 61 m long and 2.4 m deep. Each net was composed of 8 equally-sized panels of monofilament meshes arranged in an arithmetic progression. Bar measures of the meshes were 13, 25, 38, 51, 64, 76, 89, and 102 mm. Gill nets were fished in all available habitat types and were variously set at the surface, on the lake bottom, or suspended throughout the water column in shallow areas. Most nets were set perpendicular to the shore; the 13-mm mesh was usually, but not always, fished toward shore. Gill nets were set in all months of the year, but most were set in January through May.

A total of 12,288 white bass was captured in 1,428 net sets. Total length and mesh size in which it was captured were recorded for each white bass; no information on the mode of capture, whether by wedging or tangling, was recorded.

Catches from the 25-, 38-, 51-, and 64-mm meshes, which included 97% of all white bass captured, were unimodal and slightly skewed (Fig. 1). Therefore, I used a normal-skew model to determine mesh-size selectivities following the methods of Regier and Robson (1966). I standardized selectivities, as suggested by Regier and Robson (1966), so that maximum selectivity for each mesh was 1.0. These standardized selectivities give the probability of capturing a white bass of given length, in a mesh of given size. I used inverses of these selectivities to calculate weighting factors for each length class-mesh size combination. To prevent fish with

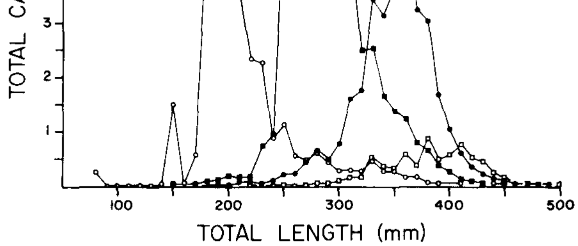

Figure 1. Size composition of white bass catches in 25-, 38-, 51-, and 64-mm mesh panels.

large weights from having undue influence, no fish was given a weight greater than 20.0.

To examine the effects of adjusting gill net data for mesh size-selectivity, I compared values of 2 size-structure indices, proportional stock density (PSD, Anderson 1980) and relative stock density (RSD, Wege and Anderson 1978), before and after adjustment for mesh-size selectivity. PSD is defined as the proportion (× 100) of stock-size fish that are also of quality length; RSD is defined as the proportion of stock-size fish that are also of preferred length. Stock, quality, and preferred lengths for white bass are 15, 23, and 30 cm, respectively (Anderson 1980, Anderson and Gutreuter 1983). Adjusted values of PSD and RSD are referred to as APSD and ARSD, respectively, throughout this paper. For samples in which the number of stock-size fish was ≥20, I compared adjusted and unadjusted size-structure indices graphically and with linear regression. Regression results for log- and arcsine-transformed variables were concordant with those for the untransformed variables, therefore results for the untransformed variables are presented here. All analyses were conducted using SAS (SAS Inst. 1985).

Results

Total lengths of white bass captured in gill nets varied between 80 and 500 mm (Fig. 2). There were 3 modes in catch, at 200 mm, 280 mm, and 330 mm; based on statewide age and growth studies (TPWD, unpubl. data), these modes correspond with age classes 1, 2, and 3, respectively.

The 13-, 76-, 89-, and 102-mm meshes captured few white bass; these meshes represented 50% of the total fishing effort, but accounted for <3% (N = 306) of all white bass captured with gill nets. Small sample sizes and the restricted length

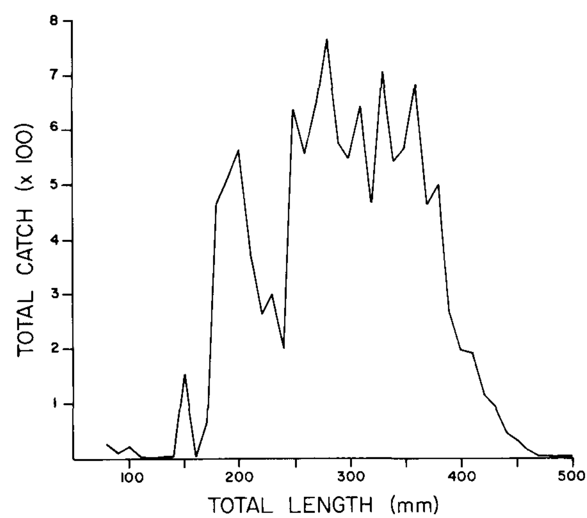

Figure 2. Length-frequency distribution of white bass captured in gill nets from 55 Texas reservoirs.

ranges of white bass captured in these meshes preclude a detailed analysis of selectivity; however, I did calculate mesh size-selectivities and weights for adjusting size-structure indices.

Length frequencies of white bass captured in the 25-, 38-, 51-, and 64-mm mesh panels were unimodal and slightly skewed (Fig. 1). Skew in length-frequency distributions was toward larger fish in the 25- and 38-mm meshes and toward smaller fish in the 51- and 64-mm meshes. The sharply peaked catches, especially for the 25-, 38-, and 51-mm meshes, suggest that wedging was the primary mode of capture. The length-frequency distribution of white bass captured in the 64-mm mesh was comparatively broad, a possible indication that tangling was an important mode of capture (Trent and Pristas 1977) or that there is greater variation in condition (i.e., "plumpness") in white bass susceptible to capture in this mesh.

Selectivity curves for the 25-, 38-, 51-, and 64-mm meshes are shown in Figure 3; these meshes were most selective for white bass with total lengths 150, 260, 370, and 480 mm, respectively. Efficiencies of 1 or more of these meshes were greater than 0.75 for all size classes of white bass between 150 and 430 mm, except for the 200-mm size class.

Forty-seven percent of sample PSDs were between 10 and 91 (Fig. 4). Within this range, differences between PSD and APSD varied between -17 and $+28$, with a mean absolute difference of 5.6. When PSD was ≤ 10 or ≥ 91, differences between PSD and APSD varied from -3 to $+13$, with a mean absolute difference of 0.6. Eighty-four percent of sample RSDs were between 10 and 91, differences between RSD and ARSD ranged between -29 and $+22$, with a mean absolute difference of 6.7. When RSD was ≤ 10 or ≥ 91, differences between RSD and ARSD ranged between -17 and $+10$, with a mean absolute difference of 2.0. Regressions of APSD on PSD (APSD = $-0.02 + 1.00 \times$ PSD) and ARSD on RSD (ARSD = 2.76 + $0.97 \times$ RSD) were both significant ($P < 0.0001$). Slopes of these regressions were not significantly different from 1.0 ($P > 0.05$), suggesting there are no detectable systematic differences, or biases, between adjusted and unadjusted values of these indices.

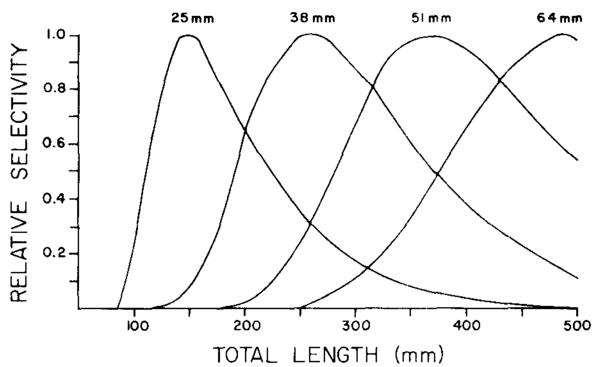

Figure 3. Selectivity curves for white bass in 25-, 38-, 51-, and 64-mm mesh panels.

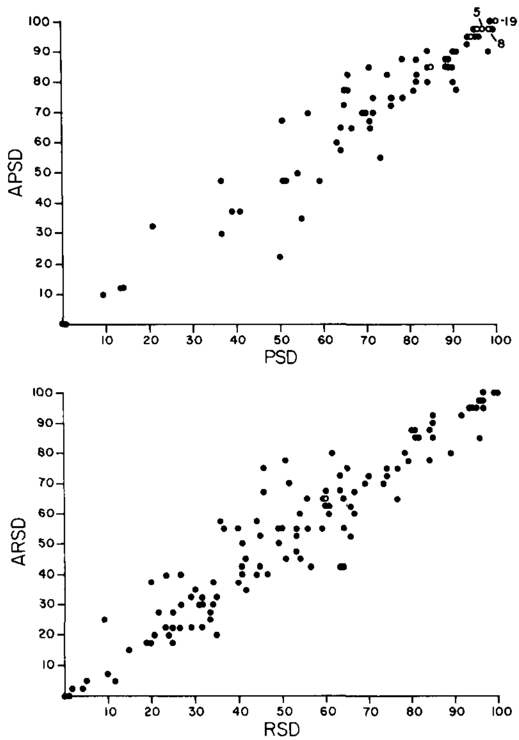

Figure 4. Scatterplots of adjusted PSD (APSD) versus PSD, above, and adjusted RSD (ARSD) versus RSD, below, for white bass in Texas reservoirs. Sample sizes are 124 for PSD and 123 for RSD. Open circles denote 3 or more coincident points; the number of observations is indicated when more than 3 points were coincident.

Discussion

All sizes of white bass, total lengths 150–430 mm, frequently encountered in TPWD gill net collections were efficiently sampled by a combination of 4 meshes: 25, 38, 51, and 64 mm. White bass <150 mm were uncommon in gill nets because sampling was primarily in winter and spring before the white bass spawn; white bass >430 mm were infrequently captured because they are naturally rare. Selectivities for the 25-, 38-, and 51-mm mesh panels were high (>0.75) over relatively broad ranges (80 to 160 mm) of total lengths. These ranges are broader than those reported by Regier and Robson (1966) and Ehrhardt and Die (1988) for similarly sized meshes and fish of comparable lengths. Berst (1961), Ehrhardt and Die (1988), and Winters and Wheeler (1990) reported that spatial and temporal variation in condition can influence estimates of mesh size-selectivity. My collections span a 7-year period, include catches from several locations within each of 55 reservoirs, and encompass wide ranges in condition for each length class of white bass. Variation in condition probably has little affect on my estimates of the lengths of white bass for which each mesh is most selective; however, this variation probably does cause selectivities for other lengths to be slightly overestimated. This variation would result in the underestimation of weights necessary to correct for mesh size-selectivity. The magnitude of any error associated with this statewide approach is unknown; however, the alternative, determining selectivities on a lake by lake basis, is impractical.

There was no evidence of any systematic difference between adjusted and unadjusted values of PSD and RSD. Adjustment of PSD and RSD had little effect when they were ≤ 10 or ≥ 91. At either of these extremes, fish are uniformly small or large; therefore, adjustments for size-selectivity have similar affects on both the numerator and denominator of PSD and RSD.

Mean absolute differences between adjusted and unadjusted PSD and RSD were 5.6 and 6.7, respectively, for values of PSD and RSD between 10 and 91. Although these differences appear small, intermediate values of both indices are those most likely to be of interest to managers. PSD and RSD are used to identify unbalanced populations of sport fishes (Anderson and Weithman 1978) and to set management goals consistent with the production of fisheries with desirable properties. Anderson (1980) suggested that PSD for largemouth bass *Micropterus salmoides* populations should fall between 40 and 70. If a comparable target range were adopted for white bass, the mean absolute difference between PSD and APSD (= 5.6) would represent 19% of that range—on average, about 1 sample in 5 would be misplaced either in, or outside, the target range.

Willis et al. (1985) reported that unadjusted gill net data significantly overestimated PSD and RSD in white bass populations in Kansas. Differences between their findings and mine are the result of differences in methods and underlying assumptions. Willis et al. (1985) never directly or indirectly estimated mesh size-selectivity; instead, they used a method of their own development to adjust length-frequency data for differences between observed and expected catches. In particular, Willis et al. (1985) assumed that catches of smaller fish should always be greater than those of larger fish and, if they were not, adjusted catches of smaller fish upward by linear extrapolation from catches of larger fish. Weights used to adjust PSD and RSD were derived from these adjusted catches. If small fish are abundant, but not sampled, the method used by Willis et al. (1985) might be reasonable; however, if small fish are actually scarce, this method will give excessively large weights to small fish and, thereby, bias estimates of PSD and RSD downward.

The scarcity of small white bass (total length <150 mm) in my samples reflects a true scarcity in the populations sampled. As noted above, sampling was primarily in spring and young-of-year white bass were not present. It is more difficult to determine why small white bass were scarce in samples collected by Willis et al. (1985). They sampled in fall, but collected few white bass less than about 170-mm in total length. However, Willis et al. (1985) used a 25-mm mesh gill net as part of their standard complement. My results indicate the 25-mm mesh is highly selective (>0.90) for white bass with total lengths between 130 and 170 mm. It seems likely that if white bass of this size range were the most abundant size class present, as explicitly assumed by Willis et al. (1985), they would have been sampled more abundantly.

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