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Reliability of Fisher-Reported Total Lengths

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SHORT PAPERS AND NOTES

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RELIABILITY OF FISHER-REPORTED TOTAL LENGTHS.—Reliable fish size information is essential for successful fisheries management. For example, scientists and managers often rely upon fisher-reported lengths to estimate life history parameters that may lead to regulations like size limits. This is especially true with respect to mark–recapture studies for estimating growth rates of fish measured at release by biologists and by fishers at recapture. The accuracy, precision, or bias of measurements made by either group is seldom known, but the measurements are generally assumed to be close representations. The few studies that have been conducted over the past 30 years to examine biologists' measurement error generally report small and unbiased errors (Ferguson et al., 1984; Gutreuter and Krzoska, 1994; Phelps et al., 2012; Bunch et al., 2013). However, results from the only studies that have examined fishers' measurement error indicate that fisher-reported lengths are less precise than biologists' measurements, in part because of digit bias (Ferguson et al., 1984; Green et al., 1987; Page et al., 2004). In addition, the accuracy of fisher-reported lengths may vary among species, fish length, and the presence of size limit regulations. Since the management implications of measurement error are potentially substantial, additional research is warranted (Bunch et al., 2013).

A 24-yr tagging study in Texas bays provides an opportunity to examine further the reliability of fisher-reported measurements. The Texas Parks and Wildlife Department (TPWD) included sheepshead (*Archosargus probatocephalus*) as one of five species tagged by TPWD biologists during 1975 through 1999 to estimate life history parameters, including growth (Bowling and Sunley, 2003). Maximum total length (TL), measured with the tail compressed, was measured by trained TPWD fishery professionals for each tagged fish. Fishers recapturing tagged fish were asked to report their catches to TPWD, including the total length of each fish (without stressing the need to compress the tail). Initial growth calculations resulted in a surprisingly large number of negative values. It is not unusual for negative growth (i.e., length at recapture less than length at release) to be encountered in tagging studies that rely upon fisher-reported lengths (Quinn and Deriso, 1999). Growth rate

estimates can be affected by many factors, including tagging trauma, partial loss of the tail from disease or predation after tagging, size limits, reporting accuracy, and measurement type, technique, accuracy, and precision (Page et al., 2004; Bunch et al., 2013). The large number of sheepshead with negative growth suggested possible systematic error. Bunch et al. (2013) advised fisheries professionals to understand how measurement error can influence the interpretation of fisheries data. The focus of this research shifted from estimating sheepshead growth rates to exploring the reliability of reported lengths.

Materials and Methods.—Sheepshead were caught along the Texas coast during routine and special TPWD sampling with a variety of gear from Nov. 1975 through Dec. 1999 (Osburn et al., 1979; Bowling and Sunley, 2003). Healthy fish were measured to the nearest millimeter maximum TL and released at the capture site after a uniquely numbered, internal anchor tag with external streamer was inserted into the abdominal cavity by TPWD fisheries professionals. The tagging program was publicized through several media, and anyone catching a tagged fish was asked to identify him or herself as a sport or commercial fisher and provide the date, location, and length of each fish. A range of monetary rewards was provided to encourage reporting of tagged fish. All TPWD-reported data were considered accurate, but the accuracy of fisher-reported data was unknown and unverified.

Recaptured fish were reported through June 2005, and only fish with both release and recapture lengths and dates (to the nearest day) were used in this study. Daily absolute growth rate for each recaptured fish at liberty for more than 1 d was calculated as the difference between TL at release and recapture divided by the days between release and recapture (days at liberty). Lengths reported by fishers were converted to millimeters before growth rates were calculated. Differences in mean TL at release and recapture, change in TL, days at liberty, and growth rate for fish reported by sport and commercial fishers were analyzed using Kruskal–Wallis one-way, nonparametric analysis of variance (Sokal and Rohlf, 1969). Data were combined when no significant ($P = 0.05$) differences were found. The effect of a minimum size limit (305-mm TL, effective Sept. 1988) on growth rates was examined using Kruskal–Wallis

TABLE 1. Mean growth statistics for recaptured tagged sheephead in Texas bays during Nov. 1975–June 2005.

Recaptured by	Number of fish	Mean TL (mm)		Mean days at liberty (SE)	Mean growth (mm/d) (SE)
		Release (SE)	Recapture (SE)		
Sport	82	388 (7)	393 (8)	166 (21)	−0.18 (0.18)
Commercial	10	379 (24)	369 (28)	202 (65)	−0.92 (0.64)
Unknown	1	390	343	69	−0.68
All fishers	93	387 (6)	390 (7)	169 (20)	−0.27 (0.17)
TPWD	7	327 (29)	353 (32)	200 (45)	0.13 (0.04)
All	100	383 (6)	388 (7)	171 (19)	−0.24 (0.16)

analysis of variance. Fish less than 357 mm were excluded from this analysis because only three fish <357 mm were tagged after the size limit was imposed, and all fish caught thereafter were larger than 357 mm. The effect of the minimum size limit on fisher-reported lengths was examined using all fisher-reported data and forward stepwise multiple linear regression (Draper and Smith, 1988).

Results.—Lengths and capture dates at both release and recapture were obtained for 100 tagged sheephead (93 recaptured by fishers and 7 by TPWD). Lengths of 46 of the fisher-reported recaptured fish were less than the corresponding TPWD-measured release lengths

(i.e., negative growth), including 41 of 82 sport-caught fish, 4 of 10 commercial caught fish, and one fish reported by an unknown fisher. Lengths of four fisher-recaptured fish (three caught by sport and one by commercial fishers) did not change between release and recapture (330–420 mm at release; 25–336 d at liberty). Mean length at release and recapture and mean days at liberty of sport-caught fish were not significantly ($P > 0.05$) different from commercially caught fish (Table 1). None of the seven TPWD-caught fish were smaller at recapture than at release, but the length of one TPWD-recaptured fish was unchanged after 13 d at liberty.

Mean absolute daily growth of TPWD-measured fish was 0.13 mm/d. Mean growth rate of all

Fig. 1. Daily growth rates (mm/d) of fisher-reported recaptured tagged sheephead (*Archosargus probatocephalus*; Nov. 1975–June 2005) caught in Texas bays (A) before and (B) after the imposition of a 305-mm TL minimum size.

Fig. 2. Relationship between daily growth rates (mm/d) of fisher-reported recaptured tagged sheephead (*Archosargus probatocephalus*; Nov. 1975–June 2005) and size at release caught in Texas bays before (circles) and after (triangles) the imposition of a 305-mm TL minimum size.

fisher-reported fish was -0.27 mm/d (Table 1); I found no significant difference between mean growth for sport-reported fish (-0.18 mm/d) and commercial-reported fish (-0.92 mm/d). Mean growth rate of 34 fish caught after the minimum size was imposed (-0.03 mm/d; Fig. 1B) was significantly greater (Kruskal–Wallis statistic = 4.6805; $P = 0.03$) than the mean rate for 33 fish caught before the size limit (-0.77 mm/d) was imposed (Fig. 1A). Growth rates were unrelated to size at release (Fig. 2) or days at liberty (Fig. 3).

Fishers reported most lengths in whole inches (53 of 93 fish) or 0.5 inch (17 fish) both before (Fig. 4A) and after (Fig. 4B) the imposition of the 305-mm TL minimum size limit.

The reported size at recapture (Y) was significantly ($P < 0.05$) correlated with the size at release ($X1$), time at liberty ($X2$), and the minimum size limit ($X3$). The relationship explained 68.1% of the variation in Y and could be expressed as

$$Y = 75.1 + 0.739(X1) + 0.11(X2) + 26.4(X3)$$

where Y and $X1$ are TL in millimeters, $X2$ = days, and $X3$ is 0 without the size limit and 1 with the size limit.

Discussion.—The TPWD tagging program is typical of most mark-recapture studies, i.e., catch fish, measure, tag, release, receive recapture information, and estimate parameters without examining data reliability. This is especially true for the accuracy and precision of length measurements. However, measurements made by trained biologists following standard protocols appear reliable. Gutreuter and Krzoska (1994) found that expected coefficients of variation of in situ TL of bluegill (*Lepomis macrochirus*), common carp (*Cyprinus carpio*), and black crappie (*Pomoxis nigromaculatus*) were nearly zero (regardless of length). They concluded that TL can be measured precisely under field conditions. Bunch et al. (2013) reported that small errors were associated with fish length measurements by fisheries professionals in Colorado. Phelps et al. (2012) reported that biologists

Fig. 3. Relationship between daily growth rates (mm/d) of fisher-reported recaptured tagged sheephead (*Archosargus probatocephalus*; Nov. 1975–June 2005) and days at liberty caught in Texas bays before (circles) and after (triangles) the imposition of a 305-mm TL minimum size.

inaccurately measured shovelnose sturgeon (*Scaphirhynchus platyrhynchus*) about 5% of the time.

Results of this study suggest that fisher-reported sheephead TLs were inaccurate, or at best imprecise. If fishers measured each TL using the technique followed by TPWD, then the measurements are simply less precise than the TPWD measurements. Unfortunately, the technique used by fishers to determine each TL is unknown. Indeed, the number of fish actually measured by fishers is unknown. A more definitive conclusion concerning accuracy would require measurements of the same fish by both TPWD biologists and fishers at the same time, but such data do not exist. Assuming that fisher-reported lengths were accurate, they were at least less precise than TPWD measurements, and they exhibited digit bias. Most fisher-reported lengths were reported in whole inches; TPWD measurements at release were made to the nearest millimeter (not an uncommon result for these types of tagging studies). Ferguson et al. (1984) and Green et al. (1987) found that sport anglers in Texas reported lengths of tagged red drum

(*Sciaenops ocellatus*) imprecisely, in part because of digit bias. Page et al. (2004) also reported digit bias in angler-reported walleye (*Sander vitreus*) lengths in Mille Lacs, Minnesota. Imprecision can be more problematic when growth is relatively small as compared to the imprecision in the measurement. Growth of a few millimeters is unlikely to be detected when TL measurement is to the nearest 25 mm (1 inch). Further, as fish size increases, the influence of the measurement scale decreases.

A mean negative growth rate for fisher-recaptured fish was unexpected. Matlock (1992) successfully used data from recaptured tagged sheephead in Texas in the 1960s to estimate von Bertalanffy growth equation parameters. Growth rates for some fish were negative, but not as many as found in this study. Further, Ferguson et al. (1984) and Green et al. (1987) found that fisher-reported red drum lengths were accurate. The inconsistent results between sheephead and red drum may have been related to differences in caudal fin shape. Sheephead have a more deeply forked caudal fin than red drum, and if the fin is not

Fig. 4. Size (TL) of fisher-reported recaptured tagged sheephead *Archosargus probatocephalus* (Nov. 1975–June 2005) caught in Texas bays (A) before and (B) after the imposition of a 305-mm TL minimum size.

compressed fully, an inaccurate (smaller) TL measurement results. If fishers incompletely or inconsistently compressed the caudal fin, reported TL measurements less than the true TL would result. Page et al. (2004) reported that the accuracy of angler length measurements of walleye were significantly and inconsistently affected by the technique used (i.e., pinched versus unpinched) and the size of fish measured. TPWD biologists compressed the caudal fin to measure TL at release and recapture; no “negative growth” estimates resulted.

A negative mean growth rate for sheephead is also unrealistic. Although the sample size is small (seven fish) for TPWD-recaptured fish, their growth was similar to estimates from studies that did not rely upon tagged fish (Parsons and Peters, 1989; Schwartz, 1990; Beckman et al., 1991; Dutka-Gianelli and Murie, 2001). The large number of negative growth rates for fisher-reported lengths, lack of any negative growth for TPWD-reported lengths, and apparent digit bias of fisher-reported lengths are more indicative of inaccuracy than imprecision.

It is possible that tail morphology might have generally changed temporally (e.g., tail damage during spawning periods or increased predatory attacks). However, this seems unlikely. My personal observations of fish during several years

of TPWD sampling and tagging operations did not reveal any consistent substantial tail damage. But, even if large-scale temporal changes in tail morphology did occur, the effect was probably small, since most fish were tagged and recaptured during fall (Oct.–Dec.) and spring (March–May), except that about 20% were recaptured during Jan.–Feb., while <4% were released during these months.

The imposition of the 305-mm TL minimum size limit in Sept. 1988 (Anonymous, 1989) affected the accuracy of reported lengths. The size limit and the measurement instructions may have provided an incentive for fishers to compress the tail more after the limit than before to retain more fish than would have occurred without compressing the tail. The relationship between recapture lengths and release length and days at liberty was increased by 26 mm after the size limit was imposed (coefficient in multiple regressions associated with size limit). Page et al. (2004) suggested that walleye anglers were more attentive to measuring fish near slot limits than those that were obviously legal to retain. Mallison and Cichra (2004) also suggested that size limits may have an effect on the reliability of angler-reported harvest information.

Although the number of fish examined in this study may be considered small, the implications

are not. Much more attention to determining data reliability of fisher-reported lengths is needed to ensure reliable growth estimates. For example, the relationship between total length measured by TPWD and measurements that mimic techniques used by fishers at recapture could be used to convert fisher-reported lengths to TPWD-measured TL. In addition, educating and training fishers on the proper technique for measuring maximum TL could increase the utility of fisher-reported lengths, especially for fish with deeply forked tails. Detailed written and pictorial instruction when fishers purchase fishing licenses, on agency web sites, and during on-site creel interviews by biologists and law enforcement personnel are opportunities for improving the accuracy of TL measurements and compliance with fishing regulations.

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