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Maximum size of fish caught with standard gears and recreational angling

Kevin L. Pope[a,*], Gene R. Wilde[a], Daryl L. Bauer[b]

[a] *Wildlife and Fisheries Management Institute, Mailstop 2125, Texas Tech University, Lubbock, TX 79409, USA*
[b] *Nebraska Game and Parks Commission, Lincoln, NE 68503, USA*

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Abstract

We correlated maximum lengths of freshwater fishes captured during 10 years with standard gears (i.e., gill nets, boat electrofishers and trap nets) and angling from Nebraska water bodies to determine which methodology provided better estimates of maximum size of fishes produced within a given water body. In general, maximum length of fishes captured with standard gears was smaller than maximum length of fishes captured with angling. Although significant (based on sequential Bonferroni adjustment) correlation was found in only one of nine sport fishes assessed, all correlations were positive indicating a general trend between maximum size of fishes captured with these two methodologies. At present, one cannot reliably predict the maximum size of fishes that is likely to be caught with angling given the maximum size of fishes captured with standard gears during routine monitoring of a fishes population.

Keywords: Angling; Fish-collection gears; Fish size; Maximum length; Trophy fish

1. Introduction

There is considerable angler interest in catching large, trophy-sized fish (e.g., Horton and Gilliland, 1994; Hughes and Wood, 1996), which creates fisheries of substantial social and economic value (e.g., Weithman and Haas, 1982; Connelly and Brown, 1991; Kerkvleit et al., 2002). To accommodate this interest, biologists expend considerable effort monitoring and managing trophy fisheries (Gilliland and Whitaker, 1990; Cofer, 1994; Hughes and Wood, 1996; Wilson and Dicenzo, 2002). However, there currently are few, if any, programs that monitor spatial and temporal trends in abundance of trophy fish, an important first step in reliably and continually managing these fish.

Biologists use a combination of standardized fish-collection gears, including gill nets, electrofishers and trap (modified-fyke) nets, to assess inland fish populations (Murphy and Willis, 1996). However, the ability of these gears to effectively sample large fish has

* Corresponding author. Tel.: +1 806 742 6888x244; fax: +1 806 742 2280.
E-mail address: kevin.pope@ttu.edu (K.L. Pope).

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been questioned (Wilson and Dicenzo, 2002; Wilde and Pope, 2004b). We correlated maximum lengths of freshwater fishes captured with standard gears (i.e., gill nets, boat electrofishers and trap nets) and angling from Nebraska water bodies to determine which methodology provided better estimates of maximum size of fish produced within a given water body. We used maximum size of fish captured and reported by anglers because angling effort in aggregate is considerable on many water bodies, especially ones known to produce trophy fish, which increases the likelihood that rare, large individuals will be caught. Logic dictates that our proposed comparison should reveal a positive relationship in maximum sizes and, thus we cast a one-tailed test (H_0: no positive relationship between maximum size of fish captured with standard gears and maximum size of fish captured with angling; H_A: positive relationship between maximum size of fish captured with standard gears and maximum size of fish captured with angling).

2. Methods

We obtained water body-specific maximum total lengths (nearest millimeter) of fishes captured with standard fish-collection gears during 10 years (1993–2002) from the Nebraska Game and Parks Commission WinFin database. The gears (Table 1) used included gill nets, boat electrofishers and trap nets, and hereafter are collectively referred to as standard gears. We also obtained, for the same period and water bodies, the maximum total lengths (millimeter, originally reported in inches) of fishes captured by anglers and entered into the Nebraska Master Angler Awards program, which provides certificates for fishes larger than species-specific minima (Table 2). A Nebraska Game and Parks Commission employee, a permit vendor or a witness must verify all entries in this program; a witness verified most entries. We chose this program because it was purposefully designed to record catches of large fish and we believed that this program suffers little from problems typically associated with angler-supplied data. For example, a low response rate (<25%) from volunteer anglers is likely for angler-diary programs because recording every fish caught disrupts the angling trip (Connelly and Brown, 1996) and recall bias is a considerable problem for angler surveys (Connelly

Table 1
Standard gears used by Nebraska Game and Parks Commission during routine monitoring of fish populations

Species	Gear
Bluegill, *Lepomis macrochirus*	Trap net[a]
Channel catfish, *Ictalurus punctatus*	Experimental gill net[b]
Common carp, *Cyprinus carpio*	Various[c]
Flathead catfish, *Pylodictis olivaris*	Experimental gill net
Largemouth bass, *Micropterus salmoides*	Electrofisher[d]
Northern pike, *Esox lucius*	Electrofisher/experimental gill net/trap net
Walleye, *Sander vitreus*	Experimental gill net
White bass, *Morone chrysops*	Experimental gill net
Yellow perch, *Perca flavescens*	Experimental gill net

[a] Netting is 159 mm bar mesh. Trap contains two throats. Effort is based on water-body size and consists of a minimum of four net nights, which is increased until at least 100 stock-length (Gabelhouse, 1984) targeted fish are captured.

[b] Nets (45.7 m long and 1.8 m deep) are monofilament with bar mesh of 19, 25, 32, 38, 51 and 76 mm. Effort is based on water-body size and consists of a minimum of four net nights, which is increased until at least 100 stock-length targeted fish are captured.

[c] Common carp are not specifically targeted during routine sampling. Rather, incidental catches of common carp are recorded for all gears.

[d] Pulsed dc waveform is used with 5–8 A and 100–200 V. Effort is based on water-body size; at least eight 15-min stations (2 h of actual energized field) are sampled on larger water bodies, whereas at least three stations (potentially less than 15 min) are sampled on smaller water bodies. Effort is increased until 100 stock-length targeted fish are captured or until the entire water-body perimeter is sampled.

Table 2
Minimum length or weight of fishes captured by anglers (hook and line) that qualify for Master Angler Awards in Nebraska

Species	Total length (mm)	Weight (g)
Bluegill	254	454
Channel catfish	762	5443
Common carp	813	6804
Flathead catfish	813	6804
Largemouth bass	508	2268
Northern pike	914	4536
Walleye	711	3629
White bass	432	1134
Yellow perch	330	567

Eligibility requires that the angler must hook, play and land the catch. All catches must be verified by a Nebraska Game and Parks employee, a permit vendor, a witness or with photograph. Fish are eligible based on length only if they are immediately released; otherwise, fish must meet the weight requirement.

et al., 2000). In contrast, we believe most anglers take time to measure large fish when they are caught (i.e., no disruption to the angling trip) because it is an infrequent event. Further, recall bias for the Nebraska Master Angler Awards program is not an issue because there is generally a single record per trip that is verified by two people (angler and witness).

We retained for analysis nine species for which at least 325 Master Angler records were available from at least 15 public water bodies. Biologically improbable lengths were recorded in three instances; we discarded these values and used the second greatest lengths instead. We used Pearson's product–moment correlation to assess the relationship between maximum lengths of fishes captured with standard gears and angling to test the hypothesis that maximum size of fish captured with standard gears during routine monitoring of fish communities was directly related to maximum size of fish captured by recreational anglers. To control the probability of falsely rejecting null hypotheses, we used the sequential Bonferroni adjustment (Rice, 1989) with a table-wide significance of 0.05 to evaluate correlations. For all study species, we expected to observe positive correlations between maximum lengths of fish captured with standard gears and angling. We used a one-tailed binomial test (Siegel, 1956) to determine whether there was an excess proportion of positive correlations across species. Under the null hypothesis of no correlation, we would expect 50% of correlations to be positive and 50% to be negative.

To better understand the relationship between maximum lengths of fishes captured with standard gears and angling, we tested the hypothesis that maximum length of fishes caught with standard gears, on average, would be less than maximum length of fishes captured with angling. To assess this hypothesis, we used one-tailed binomial tests (Siegel, 1956) within and across species to determine whether there was an excess proportion of data pairs for which the maximum length of fishes caught with standard gears were less than the maximum length of fishes captured with angling. Under the null hypothesis of no correlation, we would expect maximum length of fishes caught with standard gears to be greatest in 50% of data pairs and maximum length of fishes caught with angling to be greatest in the other 50% of data pairs. All statistical analyses were performed with SAS software (SAS Institute, Cary, NC).

3. Results

Among the nine study species, the number of fish maximum-length data-pairs from Nebraska water bodies ranged from 19 (flathead catfish *Pylodictis olivaris*) to 148 (largemouth bass *Micropterus salmoides*; Table 3). Correlations between maximum lengths of fish captured with standard gears and angling were significant ($P < 0.02$) for channel catfish *Ictalurus punctatus*, largemouth bass, northern pike *Esox lucius* and walleye *Sander vitreus* (Fig. 1), and marginally sig-

Table 3
Range, sample size (number of reservoirs, N) and correlations of maximum total length of fishes captured with standard fish-collection gears (gill nets, electrofishers and trap nets) and angling for nine sport fishes from Nebraska water bodies

Species	N	Maximum total length (mm) with				Correlation (r)
		Standard gears		Angling		
		Minimum	Maximum	Minimum	Maximum	
Bluegill	61	170	320	254	381	0.07
Channel catfish	90	222	890	711	1143	0.36**
Common carp	38	360	890	787	1067	0.09
Flathead catfish	19	210	1150	914	1524	0.18
Largemouth bass	148	124	795	483	686	0.20*
Northern pike	43	632	1140	864	1270	0.40*
Walleye	43	580	850	711	864	0.35*
White bass	21	348	440	457	584	0.15
Yellow perch	43	124	350	279	406	0.29

* $P \leq 0.05$ for a given correlation.
** $P \leq 0.05$ for table-wide significance based on the sequential Bonferroni adjustment.

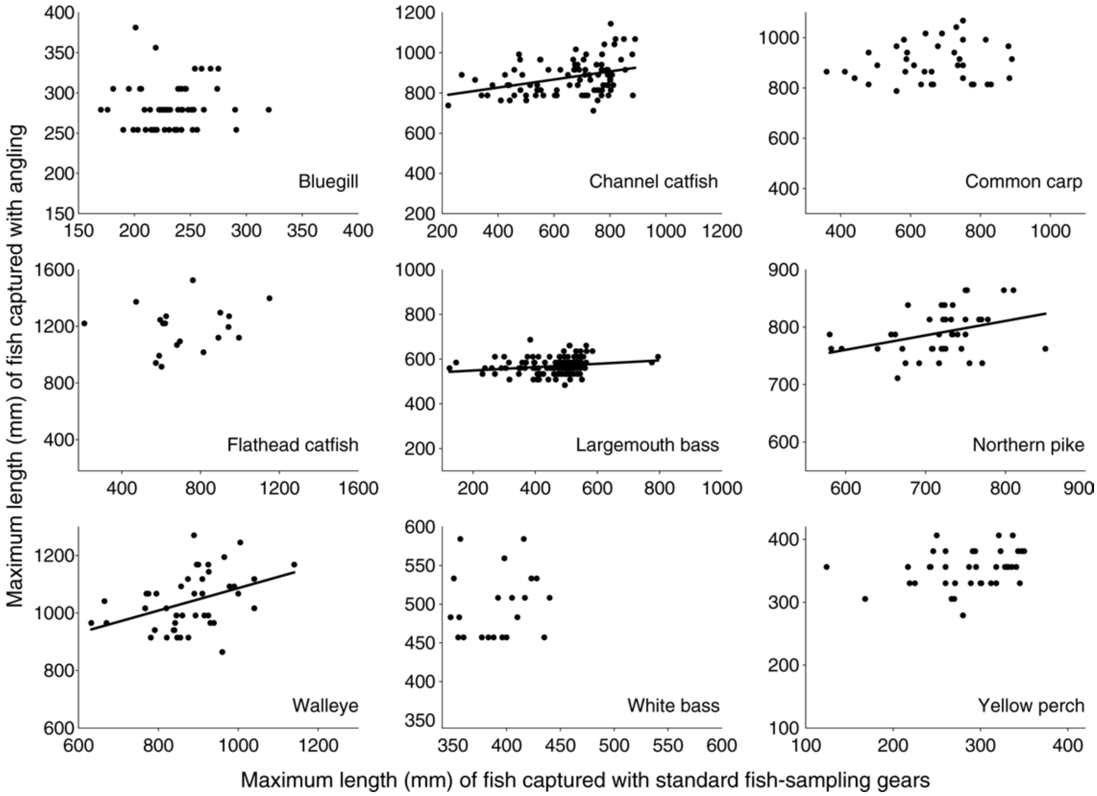

Fig. 1. Plots of maximum length of nine fishes captured with angling vs. maximum length of fishes captured with gears (gill nets, electrofishers and trap nets) traditionally used by Nebraska biologists during routine monitoring programs from 1993 to 2002. Linear relationships are presented for fishes with significant (unadjusted $P \leq 0.05$) correlation.

nificant for yellow perch *Perca flavescens* ($P = 0.058$). However, only the correlation for channel catfish was significant based on the sequential Bonferroni adjustment (Table 3).

Across species, regardless of the significance of individual correlations, there was an excess proportion of positive correlations (9 of 9; Table 3; $P < 0.001$) between maximum lengths of fish captured with standard gears and angling. This suggests there is a general tendency for maximum lengths of fish caught by anglers to increase as maximum size of fish caught with standard gears increases.

Within each species studied, there was an excess proportion (all $P < 0.0001$) of data pairs for individual water bodies in which maximum length was greatest for fishes caught with angling (bluegill: 56 of 61; channel catfish: 87 of 90; common carp: 35 of 38, flathead catfish: 19 of 19; largemouth bass: 140 of 148; northern pike: 41 of 43; walleye: 40 of 43; white bass: 21 of 21; yellow perch: 41 of 43; Fig. 1). Across species, there also was an excess proportion of data pairs for individual water bodies in which maximum length was greatest for fishes caught with angling (480 of 506; $P < 0.0001$). This suggests that angling is more selective than standard gears for capturing larger fish.

4. Discussion

There was evidence (regardless of significance, all correlations were positive) of a direct relationship between maximum lengths of fish captured with standard gears and angling. Our a priori expectation was a direct relationship because we believed that both standard gears and angling would sample large fish in proportion to their abundance in each water body.

Although our initial expectation was correct, this relationship was much weaker than we expected and in the best case, that for channel catfish, only explained 12% of the variation in the data. Therefore, at present, one cannot reliably predict the maximum length of fish that an angler is likely to catch given the maximum length of fish captured with standard gears during routine monitoring of a fish population. It is possible that substantially (orders of magnitude) increasing current effort for standard sampling would result in an increase in maximum size of fishes caught with standard gears.

There is a general tendency to view selective gears as biased, which suggests that selective gears do not capture all sizes and species in proportion to their actual abundance in the water body. All collection techniques have selectivities that are influenced by fish behavior, size and shape, experience of the collector, and habitat (Everhart and Youngs, 1981; Murphy and Willis, 1996). For standard gears, these selectivities result in seasonally different species composition and size structure (Sullivan, 1956; Latta, 1959; Hamley, 1975; Jester, 1977; Laarman and Ryckman, 1982; Hamley and Howley, 1985; Cowx and Lamarque, 1990). Angling also is species and size selective, with selectivities varing seasonally (Zolczynski and Davies, 1976; Rieger et al., 1978; Gabelhouse and Willis, 1986; Buynak et al., 1989; Kleinsasser et al., 1990; Travnichek et al., 1997). Size structure of captured fishes tend to be less for fish captured with standard gears than for fish captured with angling (Gabelhouse and Willis, 1986; Holland and Peters, 1992; Isaak et al., 1992). Likewise, our assessment documented that maximum length of fish captured with angling is often greater than maximum size of fish captured with standard gears (Fig. 1). This is compelling evidence that current practices with standard gears do not adequately sample large fish. Thus, it appears that angling may provide more representative samples of the larger size classes of freshwater fish populations than do standard gears. This size selectivity in angler-supplied data is likely advantageous for assessments of large, trophy fish because we are interested in representative samples of rare, not average, individuals.

Accurate estimates of the maximum size of fish in a population are important for biologists and ecologists because biological rates and ecological functions are size specific (Peters, 1983). For example, metabolic rate is inversely related to body size, whereas total food intake in positively related to body size. Size at hatch, size at sexual maturation and longevity are directly related to maximum size of fishes (Freedman and Noakes, 2002; van der Veer et al., 2003). Maximum length or weight is a key component in many fishery models, such as the von Bertlanffy and Gompertz growth models (Quinn and Deriso, 1999). Given the weak relationship between maximum length of fishes captured with standard gears and angling, parameters likely would be different for models developed using data collected with standard gears than for models developed using data collected with angling. We predict that a more accurate estimate of maximum length for sport-fish populations will be obtained when measured directly from angler-collected data (assuming sufficient angling effort and well-established data records; Wilde and Pope, 2004a) than when estimated with a Walford Plot (Everhart and Youngs, 1981) from data collected with standard gears. Further, we believe that this more accurate estimate would provide for the development of more realistic growth models and a better understanding of biological and ecological implications of variation in maximum fish size across water bodies.

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