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Assessing Angler Exploitation of Blue Catfish and Flathead Catfish in a Missouri Reservoir Using Reward Tags

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Abstract.—The Missouri Department of Conservation suspected that blue catfish *Ictalurus furcatus* and flathead catfish *Pylodictis olivaris* were being heavily exploited by anglers in 22,539-ha Harry S. Truman Reservoir in west-central Missouri. A reward tag study was initiated in 2004 to determine angler exploitation rates for both species. Three hundred blue catfish ≥482 mm total length (TL) and 194 flathead catfish ≥508 mm TL were equipped with transbody Carlin dangler reward tags in 2004 and 2005, respectively. All reward tags displayed a reward value of US$50. A 5-year post-tagging estimate of annual exploitation (*u*) was calculated with a 25% annual correction for angler nonreporting and a one-time correction for tag loss. The estimated annual exploitation rates for blue catfish ranged from 25.5% to 33.4% with a mean of 28.8%. The estimated cumulative exploitation rate (*U*) at 5-years post-tagging was 81.7% for all sizes of tagged blue catfish and 92.4% for tagged blue catfish ≥610 mm TL. The estimated annual exploitation rates for flathead catfish ranged from 0% to 3.9% with a mean of 1.8%. The estimated cumulative exploitation rate at 5-years post-tagging for flathead catfish was 8.8%. These exploitation rates indicate that blue catfish are being heavily exploited while flathead catfish are not. Of all the reward tagged blue catfish that were reported by anglers, 7% were reported as released while 22% of the reported flathead catfish were released. These results are being used to examine possible regulation changes to protect the blue catfish fishery at Truman Reservoir.

Introduction

Reward tagging studies are commonly used to determine angler exploitation rates on a variety of sport fish species in large reservoirs (Serns and Kempinger 1981; Weaver and England 1986; Larson et al. 1991; Muoneke 1994; Pegg et al. 1996; Colvin 2002; Schultz and Robinson 2002; Isermann et al. 2005), but few large reservoir tagging studies have been directed at catfish species. Timmons (1999) tagged blue catfish *Ictalurus furcatus* and channel catfish *I. punctatus* ≥350 mm in Kentucky Lake from 1996 to 1998 and offered rewards based on an end-of-the-year lottery drawing. Kentucky Lake supports both recreational and commercial fishing. First year angler exploitation for blue catfish was 12.3% while first year exploitation for channel catfish was 7.4%. These exploitation rates do not account for natural mortality, tag loss, or angler nonreporting. Tag returns dropped drastically in the second year for both species, and over a full 10-year period, he reported uncorrected cumulative exploitation rates to be 17% for blue catfish and 11% for channel catfish. Graham and DeiSanti (1999) tagged 2,957 blue catfish and 995 channel catfish ≥305 mm with US$5 to $100 reward tags in upper Lake of the Ozarks, Missouri from 1990 to 1994. They reported first-year annual exploitation rates ranging from 8% to 15% for the five blue catfish tagging cohorts and 6–15% for the channel catfish cohorts. These exploitation rates are not corrected for natural mortality, tag loss, or angler nonreporting. They also reported cumulative exploitation after 7 years to be 32% for blue catfish tagged in 1990 and 28% for channel catfish tagged in 1990. Holley et al. (2009) reported a range of annual ex-

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ploitation rates in Wilson Reservoir, Alabama, from 8% to 22% for blue catfish and 4–11% for channel catfish, after correcting for tag loss and a range of angler nonreporting rates (20–70%). Wilson Reservoir supports both recreational and commercial fishing and was not regulated with daily or creel limits during this study. Marshall et al. (2009) reported that estimated annual exploitation for flathead catfish *Pylodictis olivaris* in Wilson Reservoir, Alabama was between 5% and 13% after correcting for tag loss and a range of angler nonreporting rates (20–70%). Shrader et al. (2003) reported corrected annual exploitation rates for channel catfish ranging from 2% to 10% in Brownlee Reservoir, Oregon. Almost without exception, reported annual exploitation rates for catfish in large reservoirs tend to be moderately low (<15%), even after adjustments for tag loss and estimated nonreporting. Exploitation rates are generally higher for blue catfish than for channel catfish or flathead catfish.

Beginning in the mid-1990s, the Missouri Department of Conservation (MDC) suspected that blue catfish and flathead catfish were possibly being overexploited by recreational anglers in Harry S. Truman Reservoir (hereafter, Truman Reservoir) in west-central Missouri. Since its impoundment in 1979, Truman Reservoir has been extremely popular with catfish anglers. High angler catches in conjunction with purported high fishing pressure caused concern for MDC officials. Subsequently, a recreational use, activity, and benefits survey conducted on the upper South Grand River arm of Truman Reservoir by MDC during 1997–1998 (Missouri Department of Conservation 2004) showed that anglers expended more hours of effort fishing for catfish than any other species group. The survey also showed that anglers harvested 84% of all catfish that were caught. During the mid-1990s, the agency received numerous reports of what anglers described as excessive legal and illegal catfish harvest. Anglers also stated a concern over what they perceived to be a decreasing size of blue catfish.

In response to agency concerns and angler perceptions, MDC conducted a comprehensive management evaluation project from 2003 to 2009 to evaluate the blue and flathead catfish fisheries in Truman Reservoir. A primary objective of the study was to assess angler exploitation rates using reward tags.

Study Area

Truman Reservoir was constructed on the Osage River immediately upstream from 22,296-ha Lake of the Ozarks to provide flood control, recreation, and hydropower production. The reservoir covers 22,539 ha at multipurpose pool and 84,847 ha at flood control pool (U.S. Army Corps of Engineers 2009). The reservoir reached multipurpose pool in the fall of 1979 and is the largest flood control impoundment in Missouri. Truman Reservoir impounds much of the Osage River watershed in west-central Missouri (Figure 1), and together with Lake of the Ozarks (immediately downstream of Truman), they account for the majority of large reservoir blue catfish fishing in Missouri. Truman Reservoir exhibits wide water level fluctuations, with frequent 1–3-m rises following spring rains, and subsequent rapid falling levels during peak-power generation. The reservoir is moderately turbid with significant areas of standing timber and relatively shallow upper reservoir areas. The current (2010) recreational fishing regulations allow anglers to take 10 channel catfish, 5 flathead catfish, and 5 blue catfish daily, with no length limit on any of the three species. In addition to rod and reel, anglers are allowed to use set line methods such as jugs, trot lines, and limb lines, with a limit of 33 hooks per licensed angler. Commercial fishing is not permitted on the reservoir.

Methods

Tagging

Blue catfish were collected and tagged throughout Truman Reservoir for this study. We used low-frequency (15 Hz) DC boat electrofishing and jug lining

FIGURE 1. Location of 22,539-ha Harry S. Truman Reservoir in Missouri.

during April–August 2004 to collect and tag a total of 300 blue catfish ≥482 mm total length (TL). We chose to tag fish ≥482 mm TL to target blue catfish that were considered harvestable by most—if not all—anglers. We felt this approach would give us a better understanding of the vulnerability of the harvestable-sized fish in the population without having to expend reward money on smaller fish that would typically be released. Tagged blue catfish ranged in size from 482 to 995 mm TL, with a mean size of 582 mm TL. Transbody tags were attached directly below the dorsal fin, with individually numbered Carlin dangler laminated oval disk tags (Guy et al. 1996). All reward tags were marked with a $50 reward designation and contained contact information. Tagged fish were then released near their capture site. Reward tagging was accomplished at multiple locations in the upper, middle, and lower sections of the reservoir to avoid concentration of tagged fish (Figure 2). However, to minimize the number of tagged fish that might potentially migrate downlake through Truman Dam, we did not tag and release blue catfish within 8 km of Truman Dam. Graham and DeiSanti (1999) found that 12% of tagged blue catfish that were released in the lower 3 km of Truman Reservoir migrated downlake through Truman Dam and were caught by anglers in the upper portion of Lake of the Ozarks. Flathead catfish tend to be less mobile than blue catfish, which allowed us to tag and release flathead catfish even in locations close to Truman Dam.

To inform anglers of the project, informational signs were posted around the reservoir and at bait shops in the area. We also informed volunteer anglers that were involved in a concurrent reservoir catfish creel survey about the tagging project. Anglers were informed that tagged fish did not have to be harvested to claim the reward.

Using low-frequency (15 Hz) electrofishing gear, we collected and tagged 164 harvestable size flathead catfish (≥508 mm TL) during May–June 2005 with the same tagging methods described above for blue catfish. Similar to blue catfish, we chose to tag flathead catfish that were considered harvestable by most—if not all—anglers. For flathead catfish, we tagged fish ≥508 mm TL, since flathead catfish anglers release most fish below this size. Tagged flathead catfish ranged from 508 to 1,220 mm TL, with a mean size of 692 mm TL. These reward tags had the same $50 reward value as the blue catfish reward tags but were a different color and displayed a different sequence of unique identification numbers.

Tag Retention

We tagged 102 blue catfish (mostly similar in size to those with reward tags) with blank Carlin dangler tags and held them in a 0.4-ha rearing pond at Lost Valley Hatchery for 5 months in 2005 to determine

FIGURE 2. Locations of 300 blue catfish tagged with Carlin dangler laminated oval tags at Harry S. Truman Reservoir in 2004.

short-term tag loss. We chose not to hold the fish for a full year because of limited hatchery space the following spring and to avoid overwinter mortality. All 102 blue catfish were recovered alive after 5 months, but 16 (15.7%) had lost their tags. All but 5 of those 16 lost tags were recovered at the bottom of the harvesting kettle in the rearing pond after draining, and the tags were completely intact. We believe that the crowding of these fish in the harvesting kettle caused the tags to come dislodged. This was likely an indication that the two wires used to affix the transbody Carlin dangler tags did not properly span across at least one pterygiophore below the dorsal fin; hence, a secure tag anchor was not achieved for those tags. Based on our results from this retention study, we applied a onetime 15.7% tag loss for blue catfish in year 1 of the study. Flathead catfish tag retention was not studied as part of this project, but we were able to use 1-year tag retention rates from a subsequent study (Z. Ford, Missouri Department of Conservation, personal communication). We factored in a onetime 1.1% tag loss for flathead catfish in year 1.

Angler Nonreporting

To get a more accurate estimate of angler exploitation, we also had to account for angler nonreporting. Nichols et al. (1991) generated different nonresponse models using duck reward bands. The various models suggested a nonreporting rate of ~30% and ~20% for $25 and $50 bands, respectively. Those band values from 1991 equate to $35 and $69 in 2004 after adjusting for inflation (U.S. Bureau of Labor Statistics 2009). Based on the original models and the inflation-adjusted values, a $50 tag in 2004 would have an estimated nonreporting rate of approximately 25%. We used this 25% correction factor to account for angler nonreporting. Holley et al. (2009) and Marshall et al. (2009) used a range of angler nonreporting (20–70%) in their analyses to reflect the lower and upper ends used by various authors who reported on reward tag studies. Even though accounting for angler nonreporting does not yield exact estimates, we feel our value of 25% is well within reason.

Reporting Annual Exploitation

Using our tag loss estimates in year 1 and a 25% annual adjustment for angler nonreporting, we arrived at estimated annual exploitation rates (u) for both blue catfish and flathead catfish. We recognize that natural mortality also contributes to total annual mortality in these populations, and even though numerous authors have estimated total annual mortality and natural mortality for blue catfish and flathead catfish populations (Graham 1999; Graham and DeiSanti 1999; Grussing et al. 1999; Mauck and Boxrucker 2004; Makinster and Paukert 2008; Holley et al. 2009; Marshall et al. 2009), we did not conduct catch curve analyses as part of this project and thus decided not to adjust angler exploitation for natural mortality. Consequently, we believe our annual exploitation estimates are underestimates. We also reported raw tag return rates without any corrections to help compare our results to other studies where no corrections were made.

We analyzed tag return rates based on whether or not a fish was returned within a given time frame. If a tag was returned within 1 year of tagging, it was considered a year 1 return. If returned within 2 years of tagging, it was considered a second year return, and so forth. We used monthly cohorts of tagged fish and then combined the months to determine annual exploitation. Even though we have continued to receive tag returns after 5 years, we stopped analyzing tag returns after 5 years. Hubley (1963) found that 95% of tagged channel catfish that were returned by anglers from the upper Mississippi River were returned within 5 years. Timmons (1999) reported no blue catfish tag returns from Kentucky Lake after year 4.

The procedures we used to estimate annual exploitation (u_i) are as follows:

M = number of catfish marked and released in year 1,

AL_i = number of marked fish available to be harvested in year i,

NR = estimate of nonreporting, 25% in this study,

TLS = estimated rate of tag-loss (in this study, first-year tag loss was 15.7% for blue catfish and 1.1% for flathead catfish. Tag loss for subsequent years was assumed 0.0%),

H_i = catch in year i,

CR_i = fish caught and released (tags removed) in year i,

u_i = estimated exploitation rate for catfish in year i,

S = estimate of the proportion of blue and flat head catfish to survive 5 years.

Blue and flathead catfishes were analyzed independently but with the same method. The number of catfish at large at the beginning of year *i* was estimated as follows. For the initial year,

$$AL_1 = M*(1-TLS)-[(H_1+CR_1)*NR],$$

while for the beginning of subsequent years, it was estimated as

$$AL_1 = AL_{i-1}-(H_{i-1}+CR_{i-1})-[(H_1+CR_1)*NR], i=2 \text{ to } 5.$$

The annual catfish exploitation rate for each year *i* was then estimated as

$$u_i = \frac{H_i}{AL_i}.$$

We also wanted to estimate the proportion of fish that possibly survived (not including catch-and-release catfish) all 5 years for both blue and flathead catfish. The estimate of the proportion to survive all 5 years was estimated as

$$S = \prod_{i=1}^{5}(1-u_i).$$

We then used that 5-year survival estimate to determine cumulative exploitation (U) over that same 5-year period as

$$U = 1-S.$$

In addition to our analysis of tag returns for all 300 blue catfish and all 164 flathead catfish that were tagged, we also separated out tagged blue catfish (N = 94) that were at least 610 mm TL when tagged to determine exploitation rates for blue catfish at and above this size. We chose 610 mm for this part of our analysis because a 610-mm blue catfish weighs 5 lbs (2.3 kg), which is a recognizable size for most anglers, and harvest of this size and larger seems to be extremely high.

Results

Blue Catfish

The annual tag return rate for all 300 tagged blue catfish, which included harvested and released fish, ranged from a low of 7.6% in year 5 to a high of 24.2% in year 2, with a mean annual return rate of 16.4% (Table 1). The annual corrected exploitation rate (u) for blue catfish using only harvested fish ranged from a low of 25.5% in year 5 to a high of 33.4% in year 2, with a mean of 28.8%. Anglers only released 7% of the reward tagged blue catfish they reported, and in years 3–5, they harvested 100% of the tagged fish they reported. The corrected cumulative exploitation rate (U) for blue catfish after 5 years post-tagging was 81.7%.

The annual tag return rate for the 94 tagged blue catfish that were ≥610 mm TL when tagged, which included harvested and released fish, ranged from a low of 6.8% in year 3 to a high of 34.0% in year 1, with a mean of 20.3% (Table 2). The annual corrected exploitation rate (u) for blue catfish ≥610 mm TL when tagged using only harvested fish ranged from a low of 18.8% in year 3 to a high of 51.8% in year 2, with a mean of 39.4%. Anglers released only 2% of the reward tagged blue catfish that were ≥610 mm TL. The corrected cumulative exploitation (U) for tagged blue catfish ≥610 mm TL after 5 years post-tagging was 92.4%.

TABLE 1. Estimated annual (u) and cumulative (U) exploitation rates for 300 tagged blue catfish ≥482 mm TL from Harry S. Truman Reservoir, 2004–2009. A one-time 15.7% correction for tag loss was applied in year 1 and a 25% correction was applied annually to account for angler nonreporting.

Years post-tagging	Total tags returned	Harvested (%)	Released (%)	Raw return rate	Estimated tags at large at start of year	Corrected exploitation rate (u)
1 (2005)	69	61 (88)	8 (12)	0.230	300	0.259
2 (2006)	56	51 (91)	5 (9)	0.242	167	0.334
3 (2007)	27	27 (100)		0.154	97	0.300
4 (2008)	17	17 (100)		0.115	63	0.290
5 (2009)	10	10 (100)		0.076	42	0.255
Mean	36			0.164		0.288
Cumulative	179	166 (93)	13 (7)			0.817 (U)

TABLE 2. Estimated annual (u) and cumulative (U) exploitation rates for 94 tagged blue catfish ≥610 mm TL from Harry S. Truman Reservoir, 2004–2009. A one-time 15.7% correction for tag loss was applied in year 1 and a 25% correction was applied annually to account for angler nonreporting.

Years post-tagging	Total tags returned	Harvested (%)	Released (%)	Raw return rate	Estimated tags at large at start of year	Corrected exploitation rate (u)
1 (2005)	32	31 (97)	1 (3)	0.340	94	0.435
2 (2006)	18	18 (100)		0.290	39	0.518
3 (2007)	3	3 (100)		0.068	17	0.188
4 (2008)	7	7 (100)		0.171	13	0.384
5 (2009)	5	5 (100)		0.147	4	0.445
Mean	13			0.203		0.394
Cumulative	65	64 (98)	1 (2)			0.924 (U)

We examined the percentage of tagged blue catfish by 76-mm size categories (with an upper size category of blue catfish ≥788 mm TL) that were harvested in relation to their availability in the at-large tagged population (Figure 3). These data suggest that the largest tagged blue catfish (≥788 mm TL) were harvested at the highest rate (0.75), based on their availability, and the smallest blue catfish (482–558

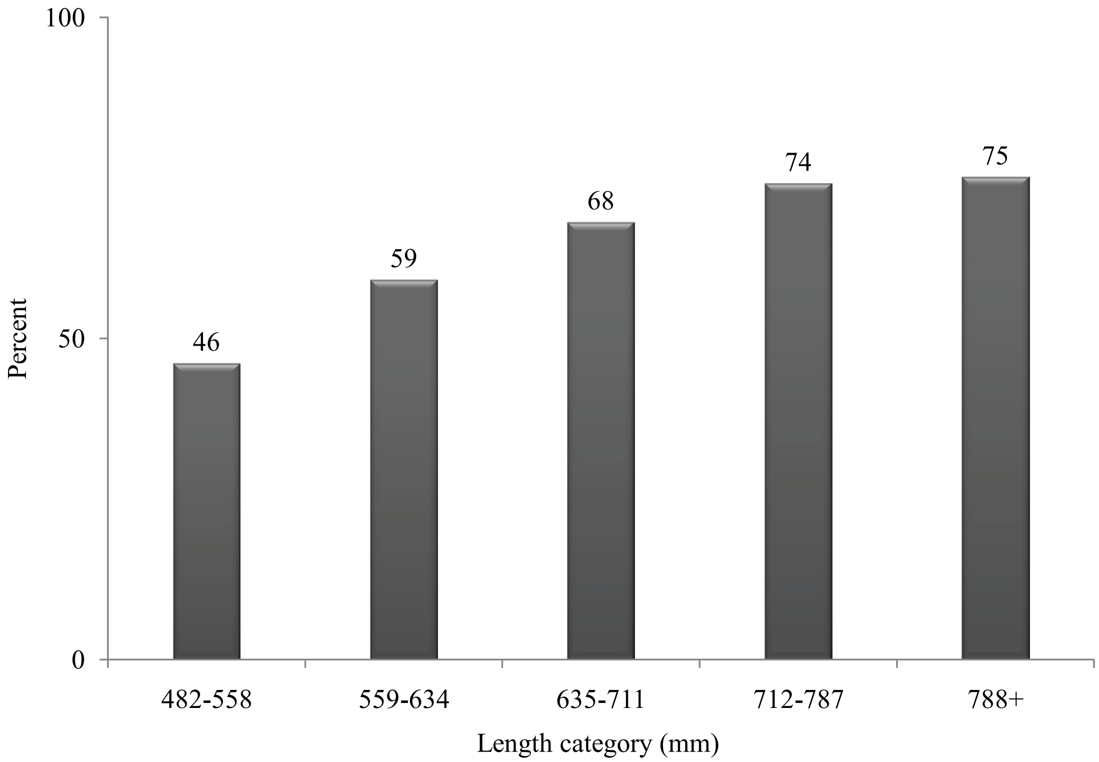

FIGURE 3. The number of at large tagged blue catfish by size bin that were harvested by anglers during 2004–2009 at Harry S. Truman Reservoir expressed as a percentage of tagged fish available.

mm) were harvested at the lowest rate (0.46), based on their availability. The rates of harvest steadily increased with the various size bins. This trend may be the result of anglers targeting the larger sizes of blue catfish, but it may also indicate that the larger sizes are more vulnerable to angler gear. In either case, the trend shows that the larger sizes of blue catfish are the most vulnerable to overharvest.

Flathead Catfish

The annual tag return rate for all tagged flathead catfish, which included harvested and released fish, ranged from a low of 0% in years 4 and 5 to a high of 4.6% in year 3 with a mean return rate of 2.3% (Table 3). The annual corrected exploitation rate (*u*) for flathead catfish ranged from a low of 0% in years 4 and 5 to a high of 3.9% in year 2 with a mean of 1.8%. Anglers released 22% of the reward tagged flathead catfish they reported. The corrected cumulative exploitation rate (*U*) for flathead catfish after 5 years posttagging was 8.8%.

Discussion

Blue catfish ≥482 mm TL in Truman Reservoir are being heavily exploited by anglers when compared to other reservoirs, even those that support commercial angling. In our study, 60% (179/300) of all blue catfish reward tags were returned by anglers within 5 years posttagging. This represents a return rate 3.5 times higher than the rate (17%) reported by Timmons (1999) at Kentucky Lake where commercial angling is allowed. The return rates at Kentucky Lake were also over a 10-year period, twice as long as our 5-year return rate. The 60% return rate in our study was nearly double the return rate of Graham and DeiSanti (1999) who reported that 32% of blue catfish reward tags from the 1990 tagging cohort were returned over a 7-year period. We documented even higher angler exploitation rates when we evaluated data for tagged blue catfish that were ≥610 mm TL. Based on consistently high electrofishing catch rates of sub-stock size blue catfish (50–189 blue catfish <305 mm TL per hour in various habitat types) and high angler catches of small blue catfish documented during a volunteer angler creel survey during 2003–2005, it is evident that Truman has consistently high blue catfish recruitment. Blue catfish growth is slow with mean length at ages 5 and 15 of 318 and 795 mm TL, respectively. Even though natural recruitment of blue catfish at Truman Reservoir is consistently high or even excessive and growth is slow, anglers are still harvesting blue catfish at a very high rate once they reach 482 mm TL, and at even higher rates once they reach 610 mm TL. Blue catfish can live in excess of 20 years (Graham 1999), which means that high exploitation in the early and middle years of life will severely limit the number of blue catfish that attain large sizes (≥762 mm TL). Even though the mean size of tagged blue catfish during our study was only 582 mm TL, we still observed high angler exploitation. It is likely that even with improved growth, this blue catfish population would still be influenced by high angler exploitation.

These results have prompted MDC to consider more protective regulations for blue catfish in Truman Reservoir. Using our exploitation rates, growth rates, and length weight data, a number of regulation

TABLE 3. Estimated annual (*u*) and cumulative (*U*) exploitation rates for 164 tagged flathead catfish ≥508 mm TL from Harry S. Truman Reservoir, 2005–2009. A one-time 1.1% correction for tag loss was applied in year 1 and a 25% correction was applied annually to account for angler nonreporting.

Years post-tagging	Total tags returned	Harvested (%)	Released (%)	Raw return rate	Estimated tags at large at start of year	Corrected exploitation rate (*u*)
1 (2006)	5	5 (100)	0	0.030	164	0.031
2 (2007)	6	6 (100)	0	0.038	156	0.039
3 (2008)	7	3 (43)	4 (57)	0.046	148	0.020
4 (2009)	0	0	0	0.000	140	0.000
5 (2010)	0	0	0	0.000	140	0.000
Mean				0.023		0.018
Cumulative	18	14 (78)	4 (22)			0.088 (*U*)

scenarios are currently being modeled with the Fisheries Analyses and Simulation Tools (FAST) software (Slipke and Maceina 2001). We are focusing most of our attention on various slot length limits that would protect the most vulnerable size-classes of blue catfish.

Reward tagging data for flathead catfish yielded very different results than what we found with blue catfish. Even though anglers target larger flathead catfish with a variety of set line methods, this species does not appear to be excessively harvested in Truman Reservoir, presumably because they are much more difficult to catch than blue catfish. Flathead catfish recruitment appears to be adequate (20 substock size flathead catfish per hour of electrofishing in 2006) and, like blue catfish, flatheads exhibit slow growth with mean length at ages 5 and 15 of 279 and 787 mm TL, respectively. Because estimated angler exploitation for flatheads falls well within what we believe to be a reasonable range (0–15%) for a long-lived species, any regulation change the agency pursues in Truman Reservoir will be targeted only at blue catfish and not flathead catfish.

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