2014

The Influence of a Rapid Drawdown and Prolonged Dewatering on Fishing Effort, Catch, and Harvest in a Nebraska Reservoir

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ABSTRACT—Red Willow Reservoir, Nebraska, experienced a rapid reduction (drawdown) in surface area, from 580 to 240 ha (59%), and prolonged maintenance at a low-water level from November 2009 until June 2012 (although the reservoir did not begin to refill until 2013 due to drought conditions). We documented changes in fishing effort, catch, and harvest at Red Willow Reservoir from two years pre-drawdown to three years post-drawdown. Fishing effort shifted from a majority of boat anglers to roughly equal representation by boat and bank anglers because of the low-water level. Effort also shifted from anglers seeking specific species to anglers simultaneously seeking all species (anything) during first-year post-drawdown, and then reverted back to anglers seeking specific species during the second and third years post-drawdown. Angler catch of fishes declined substantially post-drawdown. This case study highlights the complicated dynamics that exist among angler participation, reservoir quality, and sport-fish community. Understanding these dynamics is important in the management of fisheries, particularly when fishery managers must manage a reservoir subjected to an extreme change.

Key Words: creel surveys, recreational angling, species sought, sport fish, water drawdown

Introduction

Reservoir drawdowns occur naturally (Benejam et al. 2008) but are also planned by managers to improve the quality of sport fisheries (Heman et al. 1969; Paller 1997). Reproduction and subsequent recruitment of fishes is generally enhanced from refilling the reservoir, especially for largemouth bass (*Micropterus salmoides*) following extended periods of low-water level (Timmons et al. 1980; Meals and Miranda 1991; Allen et al. 2003), because increases in aquatic macrophytes and newly flooded terrestrial vegetation provide refuge from predation for juvenile fishes. In contrast, fluctuations in water levels during the spawning season reduce year-class strength of crappie *Pomoxis* spp. (Beam 1983). Benejam et al. (2008) observed that roach (*Rutilus rutilus*) and bleak (*Alburnus alburnus*) lost condition during a reservoir drawdown and speculated this was caused by decreases in dissolved oxygen concentration. Further, the degree of drawdown from fall to late spring was inversely related to year-class strength of coregonid fishes (Gaboury and Patalas 1984).

Reservoir drawdowns can also affect anglers, including loss of boat ramp availability, loss of amenities for bank anglers, and changes in catch or harvest rates (Heman et al. 1969; Post 2013). During periods of low water, anglers can choose to take up a different recreational activity (e.g., golf), choose to continue fishing at the reservoir and maintain their behavior, choose to continue fishing at the reservoir but alter their fishing behavior, or choose to fish a substitute reservoir within a regional fishery (Martin and Pope 2011). The influences on angling participation and catch are likely influenced by the reservoir morphology (Ploskey 1983) and the length of time that the reservoir is maintained at a low-water level as changes occur in the fish community (see above) and aesthetic conditions (Cordell and Bergstrom 1993).

During October 2009, inspectors from the US Bureau of Reclamation discovered cracking in the earthen dam at Red Willow Reservoir and initiated an emergency decrease in water level. The drop in water level mini-

Manuscript received for review, 10/8/13;
accepted for publication, 5/14/14.
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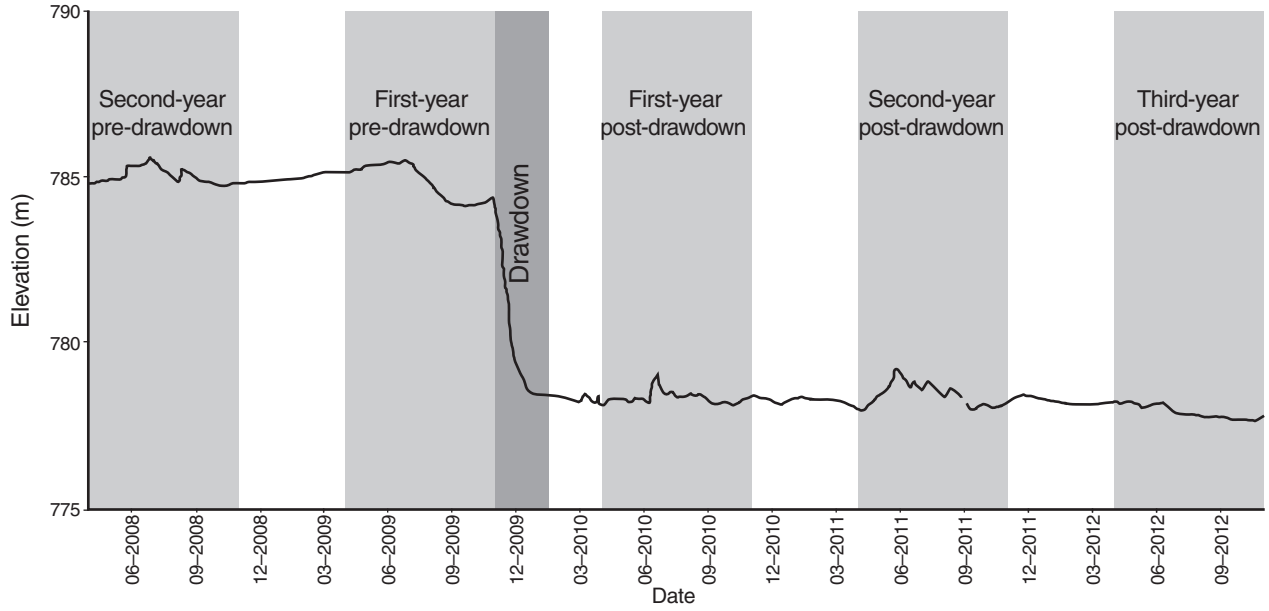

Figure 1. Water elevation (m) at Red Willow Reservoir, Nebraska, between March 2008 and October 2012. The dark gray box indicates the period of rapid drawdown of the reservoir, and the light gray boxes indicate the creel seasons two years pre-drawdown and three years post-drawdown.

mized safety risks for downstream areas and allowed construction activities to repair the dam. Following the emergency drawdown, the reservoir experienced a 59% reduction in surface area, from 580 to 240 ha. Managers maintained extremely low-water level from November 2009 until June 2012 (although the reservoir did not begin to refill until 2013 due to drought conditions). Concurrent angler surveys at Red Willow Reservoir offered an opportunity to investigate how an emergency drawdown and the subsequent extended maintenance of the low-water level affected anglers at that reservoir (Fig. 1). Specifically, the objectives of this study were to document the changes in fishing effort, catch, and harvest at Red Willow Reservoir after the water level was drawn down and maintained at an extremely low level for three years.

Methods

Study Site

Red Willow Reservoir (also known as Hugh Butler Lake; Fig. 2), located (40°21'37.20'N; 100°41'47.59'W) within the Republican River basin in southwestern Nebraska, was constructed along Red Willow Creek by the US Bureau of Reclamation during 1962. At conservation pool, Red Willow Reservoir was characterized by a water level of 787 m above mean sea level, surface area of 660 ha, and maximum depth of 15 m. There were four boat ramps available to anglers prior to the drawdown (winter 2009–2010), zero boat ramps available from drawdown until June 2010, and one boat ramp available thereafter. Prior to the drawdown, there were 56 km of brushy shoreline available to bank anglers, and more of the reservoir became accessible to bank anglers once the exposed shoreline dried after drawdown. The sport-fish community at Red Willow Reservoir was composed of channel catfish (*Ictalurus punctatus*), crappie, flathead catfish (*Pylodictis olivaris*), hybrid striped bass (*Morone chrysops* × *M. saxatilis*), largemouth bass, northern pike (*Esox lucius*), smallmouth bass (*M. dolomieu*), walleye (*Sander vitreus*), and white bass (*M. chrysops*).

Angler Surveys

We interviewed anglers (N = 1,479 parties) from 1 April to 31 October during years 2008 through 2012 to document angler participation patterns, fishing effort, catch, and harvest. We used a stratified multistage probability sampling regime (Malvestuto 1996) to determine days of interviews. Surveys occurred on 10 days each month and stratified by day-type with six weekday days and four weekend and holiday days per month. Each creel day was further stratified into two (sunrise to 1330 [morning] and 1330 to sunset [afternoon]) survey pe-

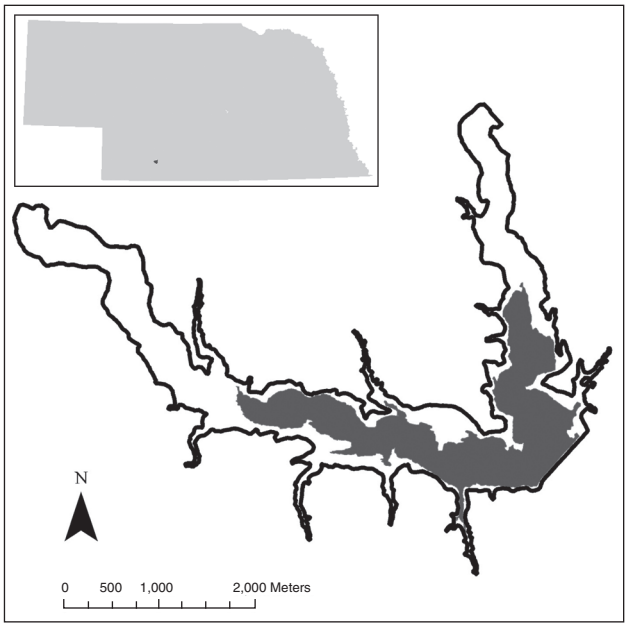

Figure 2. Red Willow Reservoir (Hugh Butler Lake) in southwestern Nebraska. The white fill with black border represents the pre-drawdown surface area of the reservoir, and the gray fill represents the post-drawdown surface area of the reservoir.

riods. We interviewed boat anglers at boat ramps and interviewed bank anglers by roving the banks. During the interview process, creel clerks measured harvested fish (total length to the nearest millimeter). The creel clerk completed a count of bank and boat anglers on the water body within an hour after a preselected randomly determined time. All methods and materials used in this study were approved by the Institutional Review Board at the University of Nebraska.

Gill-Net Surveys and Water-Level Data

We obtained data from Nebraska Game and Parks Commission for standardized sampling during fall with gill nets that targeted channel catfish, hybrid striped bass, walleye, and white bass during 2008–2011. No standardized sampling targeted largemouth bass, and standardized sampling did not occur during 2012. From these data, we calculated the mean ±SE catch per unit effort (CPUE; number of fish per night set) of stock-length fish (fish greater than or equal to a species-specific length; lengths defined in Anderson and Neumann 1996). We obtained data from the US Bureau of Reclamation website (http://www.usbr.gov/gp-bin/arcweb_hbne.pl) for water elevation and surface area.

Numerical Analyses

We calculated monthly estimates and associated variances following methods described by Malvestuto et al. (1978). The basic process of the extrapolations is as follows. First, fishing effort for each survey day was calculated by multiplying the angler count by the number of hours in the survey period adjusted by the probability (0.5 for this study) of the daily period. We calculated the mean and variance of daily effort for each stratum (weekday and weekend/holiday), weighted by the proportion of the day types per month, and summed. We calculated monthly effort and the associated variances by extrapolating the daily effort estimate and associated variance by the number of days per month. We then calculated daily CPUE for each survey day by dividing total catch for surveyed anglers that day by the total recorded trip lengths of surveyed anglers that day and multiplied the daily CPUE by daily effort (effort of time period extrapolated out to the day) to obtain total daily catch. Monthly catch and associated variance were calculated by weighting the mean and variance of daily catch for each stratum (weekday and weekend/holiday), and then these values were weighted by the proportion of the day types per month and summed, and then extrapolated by the number of days per month. For all monthly estimates, we differentiated between boat, bank, and all (boat + bank) anglers and among species caught. Concurrent creel surveys using identical methodology to that at Red Willow Reservoir provided estimates of angling pressures at proximate reservoirs on the Republican River (i.e., Enders Reservoir, Medicine Creek Reservoir, and Swanson Reservoir).

Results

Fishing effort (sum of monthly estimates ± SE) from April to October was 30,719 ± 3,061, 22,583 ± 2,011, 16,282 ± 2,169, 18,839 ± 1,272, and 8,891 ± 832 in second-year pre-drawdown (2008), first-year pre-drawdown (2009), first-year post-drawdown (2010), second-year post-drawdown (2011), and third-year post-drawdown (2012), respectively. Boat anglers comprised 86 ± 1% (mean ± SE fishing effort across years) of total effort prior to the drawdown and 50 ± 2% following the drawdown. Peak fishing effort occurred in May and June (Fig. 3), except in third-year post-drawdown, when fishing effort was similar in May through August and displayed no distinguishable peak in fishing effort. Red Willow had the second greatest amount of fishing effort

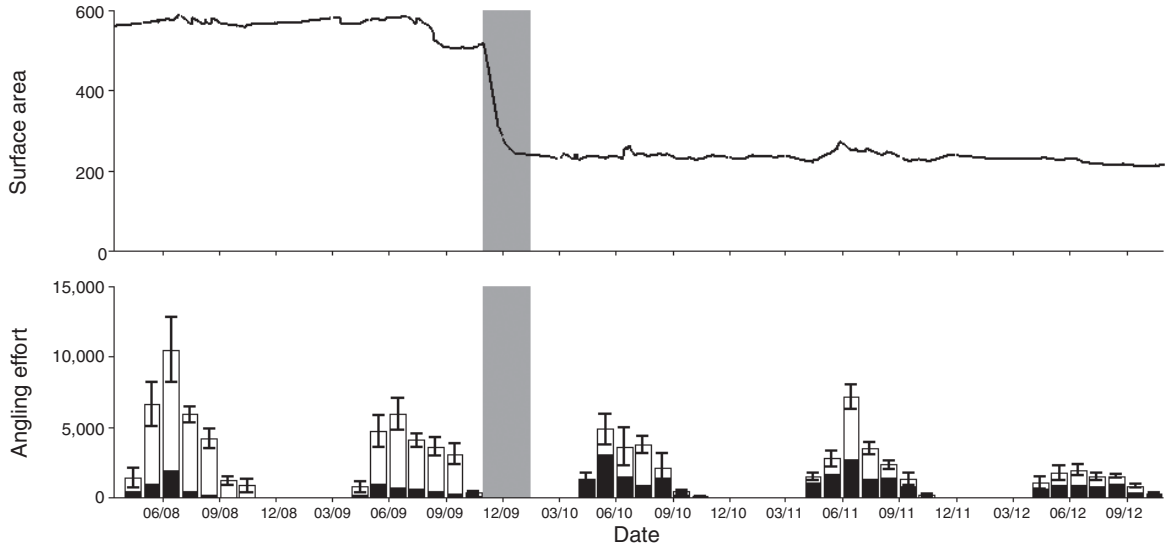

Figure 3. The surface area (ha) and fishing effort (hours spent fishing) ± SE at Red Willow Reservoir, Nebraska, between March 2008 and October 2012. The gray box in both plots indicates the period of rapid drawdown of the reservoir. Bottom plot: Black bars represent bank anglers and white bars represent boat anglers.

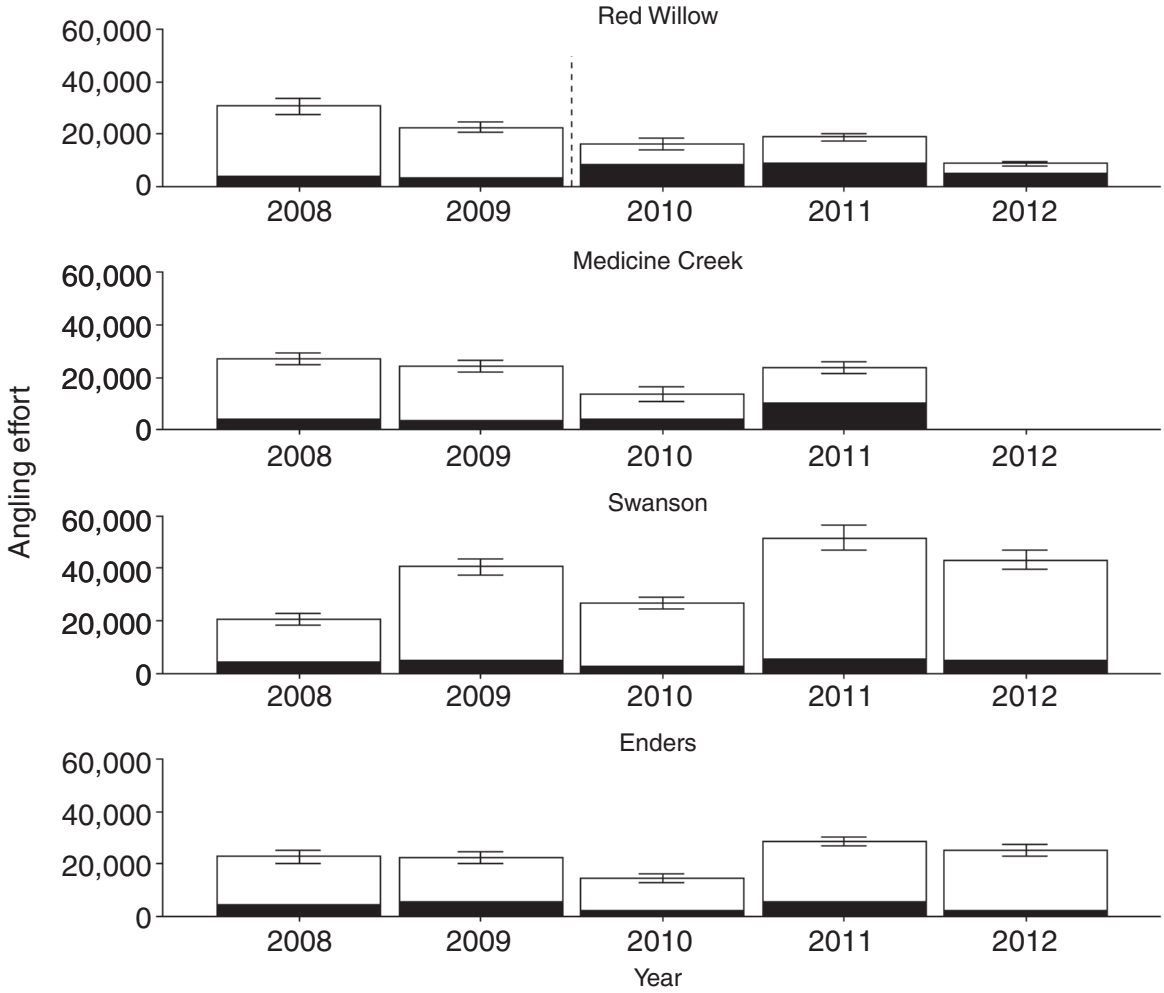

Figure 4. The total fishing effort (hours spent fishing) ± SE from April to October at Red Willow, Medicine Creek, Swanson, and Enders Reservoirs, Nebraska, between March 2008 and October 2012. Black bars represent bank anglers and white bars represent boat anglers. The dashed line indicates the period of rapid drawdown at Red Willow Reservoir.

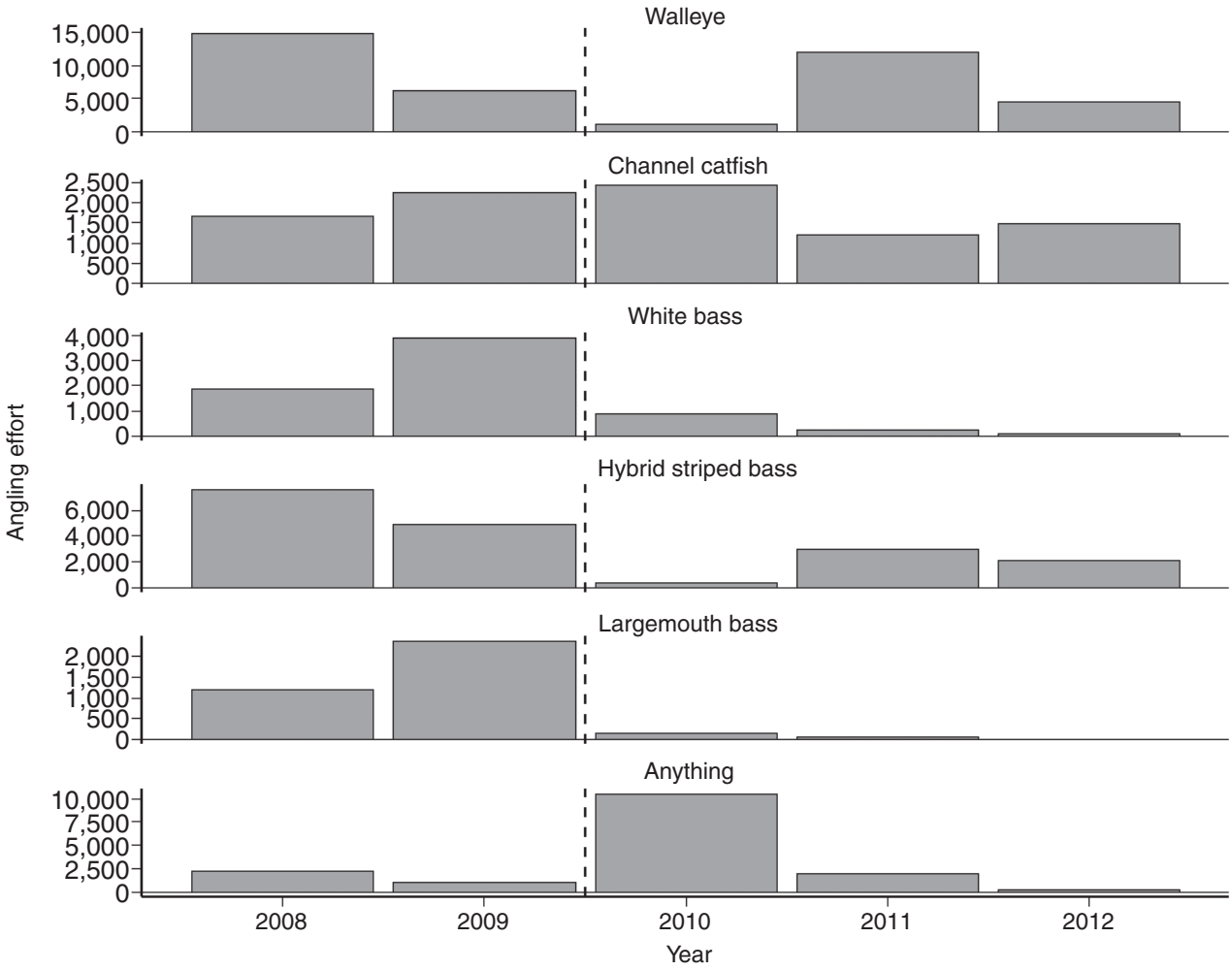

Figure 5. The fishing effort (hours spent fishing) ± SE seeking walleye, channel catfish, white bass, hybrid striped bass, largemouth bass, and anything at Red Willow Reservoir, Nebraska, between March 2008 and October 2012. The dashed line indicates the period of rapid drawdown at Red Willow Reservoir.

among the regional reservoirs prior to the drawdown, and the least fishing effort in the region by second-year post-drawdown (Fig. 4).

Anglers seeking anything, channel catfish, hybrid striped bass, largemouth bass, walleye, and white bass accounted for 94% of fishing effort at Red Willow Reservoir across all years in this study. Walleye were the most sought species, which accounted for 44% of fishing effort at the reservoir. There was an evident shift in the fishing effort for the different target groups from pre- to post-drawdown (Fig. 5). Prior to drawdown, anglers sought primarily walleye, but during first-year post-drawdown, walleye effort decreased by an order of magnitude from the previous year. Effort that targeted white bass, hybrid striped bass, and largemouth bass also decreased while effort seeking all species (i.e., anything) during first-year post-drawdown increased. Fishing effort that targeted walleye returned, but smaller in magnitude, during the subsequent years, which corresponded to a substantial reduction in effort that targeted anything. The pattern and magnitude of angling effort that targeted channel catfish appeared to be relatively unaffected by the drawdown (i.e., remained relatively constant pre- and post-drawdown).

The numbers of fish caught (released + harvested) and harvested by anglers did not increase following the drawdown for most of the species at Red Willow Reservoir (Fig. 6). There was a dramatic drop in the numbers of walleye and hybrid striped bass caught by anglers following the drawdown, and there was no evidence that this was due to an increase in the number harvested following the drawdown. The numbers of white bass caught and harvested by anglers declined following the drawdown, but not to the extent observed for walleye

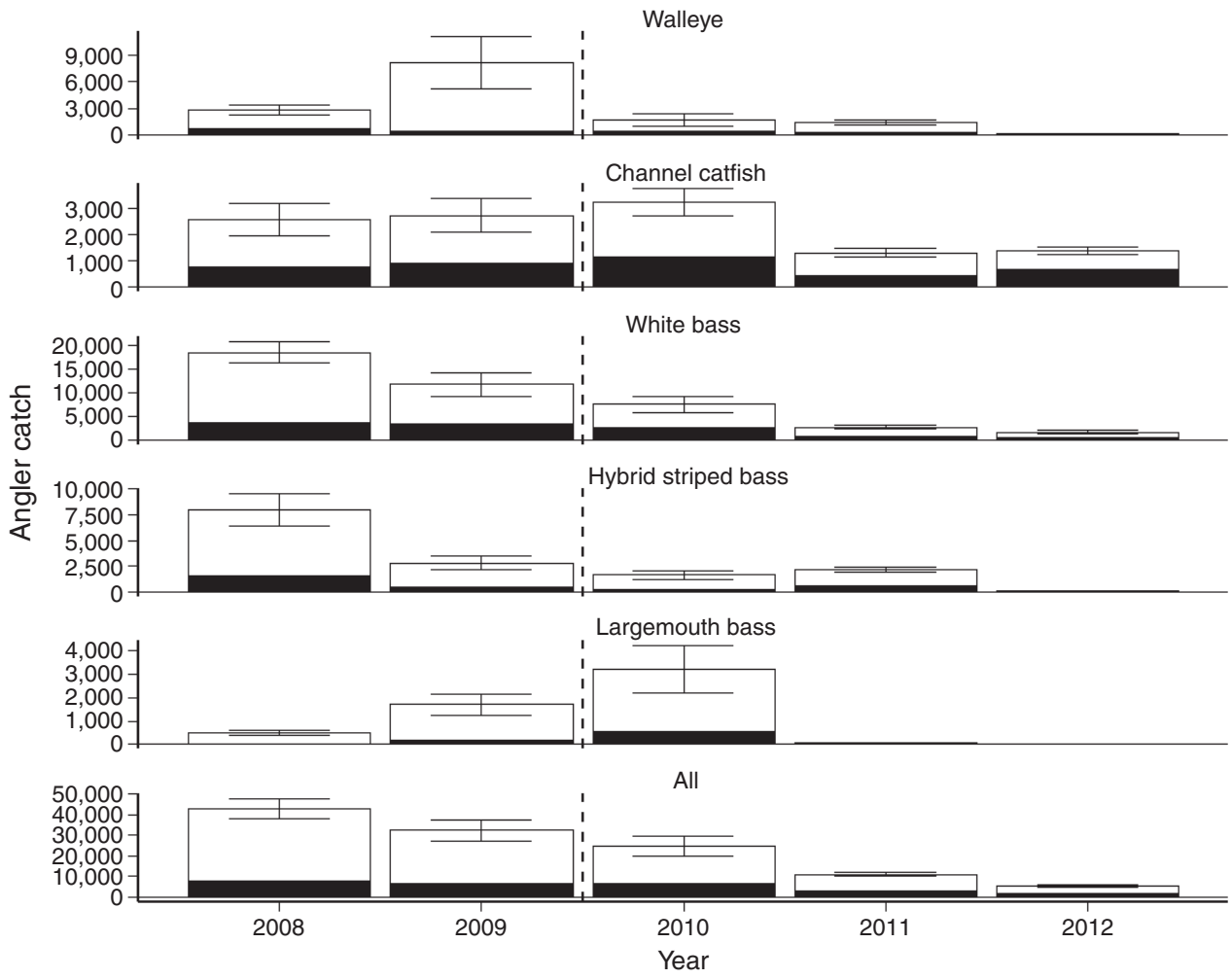

Figure 6. Angler catch ± SE for walleye, channel catfish, white bass, hybrid striped bass, largemouth bass, and all fish by recreational anglers at Red Willow Reservoir, Nebraska, between March 2008 and October 2012. White bars represent released fish and dark bars represent harvested fish. The dashed line indicates the period of rapid drawdown at Red Willow Reservoir.

and hybrid striped bass; the numbers of white bass caught declined dramatically during second-year and third-year post-drawdown. The numbers of largemouth bass caught and harvested by anglers initially increased following the drawdown (the only species for which this occurred), but similar to other species, its numbers declined to 0 during third-year post-drawdown.

Trends in gill-net CPUE were similar to trends in angler CPUE for most species assessed (Table 1). However, there was a large drop in the gill-net CPUE for hybrid striped bass during second-year post-drawdown with no corresponding decrease in angler CPUE. Similarly, the increase in gill-net CPUE for walleye during second-year post-drawdown did not correspond to an increase in angler CPUE. There was a substantial decrease in angler CPUE for hybrid striped bass and walleye during third-year post-drawdown, and a contrasting substantial increase in catfish CPUE during third-year post-drawdown.

Discussion

Although 2010 (first-year post-drawdown at Red Willow Reservoir) was a low point in fishing effort among all reservoirs in the region, fishing effort declined in subsequent years at Red Willow Reservoir, whereas fishing effort increased at proximate reservoirs (i.e., Medicine Creek, Swanson, and Enders). Interestingly, it was not until third-year post-drawdown that we observed a substantial drop in the overall effort at Red Willow Reservoir from what it had been prior to the drawdown. Even so, we observed one of the most striking changes at Red Willow Reservoir immediately following the drawdown—the composition of fishing

TABLE 1. Mean (± standard error) catch per unit effort of stock-length fish for gill nets and recreational anglers during 2008–2011 at Red Willow Reservoir, Nebraska.

Fish	Year	Gill-net catch per unit effort (number of fish per net-night)	Angler catch per unit effort (number of fish per hour-angling)
Channel catfish	2008	3.75 ± 1.11	0.08 ± 0.05
	2009	3.25 ± 0.75	0.12 ± 0.05
	2010	5.33 ± 1.76	0.18 ± 0.07
	2011	2.50 ± 1.50	0.08 ± 0.02
	2012	—	0.18 ± 0.04
Hybrid striped bass	2008	12.50 ± 1.19	0.21 ± 0.08
	2009	11.00 ± 2.12	0.18 ± 0.15
	2010	9.33 ± 1.33	0.12 ± 0.09
	2011	2.00 ± 1.00	0.13 ± 0.03
	2012	—	0.01 ± 0.01
Walleye	2008	3.00 ± 0.58	0.10 ± 0.04
	2009	4.33 ± 1.20	0.40 ± 0.33
	2010	2.67 ± 0.33	0.09 ± 0.03
	2011	7.33 ± 1.45	0.08 ± 0.03
	2012	—	0.01 ± 0.01
White bass	2008	10.25 ± 1.11	0.68 ± 0.20
	2009	2.25 ± 0.63	0.44 ± 0.18
	2010	7.67 ± 2.03	0.41 ± 0.21
	2011	2.00 ± 1.00	0.14 ± 0.04
	2012	—	0.11 ± 0.06

Note: Gill nets were not set during 2012.

effort transitioned from predominately boat anglers to roughly equal effort by boat and bank anglers. It is difficult to ascertain why there was a compositional change in fishing effort at Red Willow Reservoir, but there are several possibilities. One possible reason for the decrease in fishing effort by boat anglers was the decrease in usable boat ramps, which could have persuaded some boat anglers that fished Red Willow Reservoir to shift from fishing from a boat to fishing from the bank. This could have been the reason why the total effort did not substantially decrease during first-year and second-year post-drawdown compared to during first-year pre-drawdown, particularly if catch was not the primary motivation for anglers at Red Willow Reservoir (Driver and Knopf 1976; Fedler and Ditton 1994). Alternatively, boat anglers could have stopped fishing at Red Willow Reservoir and begun fishing at Enders Reservoir, Medicine Creek Reservoir, Swanson Reservoir, or other substitute sites, but this would have required an influx of new bank anglers for the overall effort to remain relatively consistent during this period as we observed.

Often, fishery professionals assume that anglers are highly mobile and are responsive to spatial differences (among reservoirs) and temporal differences (among years) in fish abundances (Johnson and Carpenter 1994; Carpenter and Brock 2004). We observed little change in fishing effort during first-year and second-year post-drawdown, despite decreased catches; thus, we suggest that catch and harvest were not the primary motivation factors for anglers fishing at Red Willow Reservoir. Although the total effort changed little during first-year and second-year post-drawdown, there was a corresponding shift in seeking behavior as anglers targeted all species (anything) during first-year post-drawdown. It is unknown if this shift in behavior was in response to a perceived increase in effort with an expectation that the fish community would quickly be reduced in abundance by angler harvest. If so, this perception was short-lived, as walleye and hybrid striped bass were once again the most sought species during second-year post-drawdown despite having relatively low catches. Effort that targeted channel catfish was relatively unchanged pre- and post-drawdown.

The drawdown of Red Willow Reservoir apparently set in motion a decline in the fishery, but there was no indication that this was a result of overharvest. Natural recruitment of hybrid striped bass, walleye, and white bass likely would be negatively affected by the decrease in water level as these species have highly variable recruitment in this region (DeBoer et al. 2012) and are often sustained through stocking, which did not occur in Red Willow Reservoir post-drawdown. Largemouth bass were likely to experience a substantial decline in natural recruitment after the decrease in water level, due to the loss of littoral habitat (Meals and Miranda 1991). In contrast, channel catfish natural recruitment appeared resilient to the habitat change in Red Willow Reservoir post-drawdown, though it is unclear why. Surprisingly, it took two years at an extremely low water level for there to be an observable divergence in trends of CPUE between gill nets and recreational anglers.

Though short-term drawdowns and subsequent reflooding are often used to improve the quality of the sport-fish community in reservoirs, multiple years of low water will affect fishing effort, use of boats, species-seeking behavior, and catch and harvest by recreational anglers. We observed some changes shortly after the drawdown, such as amount of effort seeking particular species and proportion of boat anglers, whereas we observed other changes several years following drawdown, such as overall effort and catches. This case study highlights the complicated dynamics that exist between angler participation, reservoir quality, and sport-fish community. Understanding these dynamics is important in the management of fisheries, particularly when fishery managers must manage a reservoir subjected to an extreme change.

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