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Cover photo: Fisheries biologists spread a net on the far edge of this typical livestock watering dugout near Six Mile Creek in South Dakota before pulling the net through the dugout to collect fishes. Photo by Charles Berry.

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Dugouts and Stream Fishes, Especially the Endangered Topeka Shiner

Introduction

The Topeka shiner (*Notropis topeka*) is an endangered fish that occurs in smaller streams of the Missouri River Basin in Missouri, Nebraska, Kansas, South Dakota, Iowa, and Minnesota. Topeka shiners have also been found in off-channel, flood plain wetlands such as oxbows, natural wetlands, and created wetlands. Created wetlands can be livestock watering dugouts and other wetlands that might be constructed through U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) conservation practices to retain water.

Stream fishes can enter a created wetland when it is hydrologically connected to the stream during a flood. These same fish can also become trapped when flooding recedes. The created wetland may be adequate or inadequate fish habitat depending primarily on the location of the wetland and on water quality that enables fish survival over winter and summer. The wetland might protect fish if they survive and reproduce in the created wetland, especially during periods of stream intermittence.

The Topeka shiner is a minnow that reaches a maximum length of about 3 inches (Wall and Berry 2006). Its olive to silvery color and dusky lateral stripe are similar in appearance to several other stream fishes (fig. 1), especially the sand shiner (*N. stramineus*), but the bright red fins of the spawning male are obvious (fig. 2). Topeka shiners have declined to 20 percent of their historic six-state range, but are still fairly common in eastern South Dakota and southwestern Minnesota.

The goals of this study were to determine whether dugouts in the flood plain function as off-channel habitat for Topeka shiners and other fishes and recommend conservation practices compatible with stream fish resources.

Excavated livestock watering impoundments, called dugouts, are constructed under Conservation Practice Standard (CPS) 378 to provide a stable water supply for livestock (Johnson et al. 1997). Information about dugouts as habitat for stream fishes may have application to other CPSs (table 1) and other states.

Project description

Study area

The Six Mile Creek Basin was selected because of the presence of Topeka shiners and approximately 70 dugouts in the basin. The Basin is a 47,000-acre, 11-digit hydrological unit; the creek is a tributary to the Big Sioux River in Brookings County, South Dakota. The creek is an intermittent stream over a shallow aquifer over most of its length.

Figure 1 Topeka shiner

Figure 2 Male Topeka shiner in breeding colors

Topeka shiner habitat and life history

A habitat model describing the association between fish presence and stream habitat is available for South Dakota streams (Wall and Berry 2006). In South Dakota streams, Topeka shiners are associated with small streams and cool, clear water, and also with moderately turbid, warm streams. The landscape surrounding Topeka shiner sites is usually grassland or pasture with fairly intact riparian zones of grass or trees that provide shade and organic matter to the stream and maintain bank stability. Kuitunen (2001) identified similar habitat associations in the Rock River in Minnesota; however, the South Dakota model may not apply elsewhere.

The species has also been found in off-channel habitats, often attaining higher densities than in the stream (Clark 2000; Hatch 2001; Thomson and Berry 2007). Topeka shiners have an interesting life history because they spawn in the clean gravel of sunfish nests. Most spawning occurs in the spring after water temperatures reach about 71 degrees Fahrenheit, and some spawning may continue throughout the summer (Hatch 2001; Kearns and Bonneau 2002).

Fish and habitat sampling

Dugouts and adjacent stream reaches were sampled seasonally with seines and traps for fishes from 2003 to 2005. Water quality measurements were made for temperature (˚C), conductivity (µs), salinity (ppt), dissolved oxygen concentration (ppm), pH, turbidity (ntu), and hydrogen sulfide presence (ppm).

Dugouts and study design

Twenty dugouts distributed from the lower to upper watershed varied in age and location from the stream. Two new dugouts were constructed for this project to monitor fish migration during flooding. Location of all dugouts was categorized by:

- connectivity with the stream
- stream order
- longitudinal location in the basin
- lateral location in the basin as determined by flood-prone frequency and distance from the stream

Connectivity was classified as:

- connected to the stream (fig. 3)
- disconnected (fig. 4)

The order (Strahler 1957) of the stream adjacent to each dugout location was determined (e.g., headwaters are first-order streams).

Longitudinal placement category was determined by dividing the basin into four quadrants representing upper to lower basin locations.

Lateral placement was categorized by three flood-frequency classes (USDA NRCS 2005) and distance from the stream. Flood frequency was determined for 16 dugouts using elevation and other data and for 4 dugouts by soil data (USDA NRCS 1995). Flood frequency classes were:

- very frequently flooded
- frequently flooded
- occasionally flooded

Distance was either:

- close (<50 ft) to the stream
- distant (>50 ft) from the stream

Table 1 CPSs that create flood plain depressions to hold water and their potential as adequate or inadequate fish habitat

CPS code	CPS title	Inadequate fish habitat [1]	Adequate or inadequate fish habitat [2]
378	Pond, dugout and embankment pond		x
436	Irrigation storage	x	
447	Irrigation recovery	x	
552b	Irrigation pit	x	
656	Constructed wetland for water treatment		x
658	Wetland enhancement		x
659	Wetland creation		x

1 Water is usually pumped out for irrigation so any fish trapped in these wetlands after flooding would die.

2 Depending on location in the basin and construction features of the wetland.

The close zone is essentially the riparian buffer zone.

The two lateral classifications, distance from the stream and flood frequency, are not necessarily related (fig. 5). Dugout 1 is in the frequently flooded zone and is distant from the stream, whereas dugout 2 is also distant but is in an occasionally flooded zone. Dugouts 3 and 4 are both close, but dugout 3 is occasionally flooded, and dugout 4 is frequently flooded. Redundant representatives of each situation were included in the study so that each dugout location variable could be analyzed separately. Statistical analyses proved these variables to be useful, independent predictors of Topeka shiners.

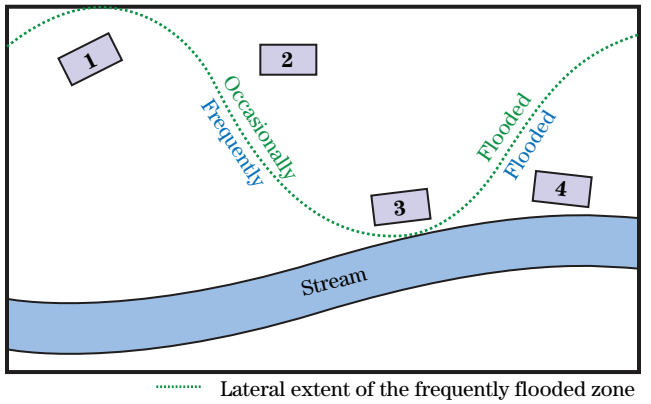
Essential results

- Fish assemblages in dugouts (22 species) and the stream (20 species) were similar in species presence, richness, and relative abundance.
- Fish inhabited 14 of 20 dugouts; 7 of 20 dugouts contained Topeka shiners. Three dugouts contained Topeka shiners each year of the study, and two dugouts contained Topeka shiners during each of seven sampling seasons.
- Highest Topeka shiner abundance was in two dugouts that were frequently flooded, remained disconnected throughout the study, and were within the 50-foot riparian buffer zone of the stream.
- In the lateral dimension of the flood plain, fish presence was more likely in dugouts that were disconnected from the stream but close and frequently flooded than in dugouts in other categories (i.e., connected, distant, occasionally flooded). Topeka shiner abundance was higher in disconnected dugouts that were close and frequently flooded than in other dugouts.
- In the longitudinal dimension of the watershed, Topeka shiner presence (and fish presence) was higher and Topeka shiner abundance greater in dugouts near higher order streams, but longitudinal placement (upper to lower basin) was not a significant factor in Topeka shiner presence.
- Fish presence was positively correlated to dissolved oxygen concentration.
- Fish predators such as black bullhead and sunfishes coexisted with Topeka shiners, perhaps because of the abundance of buffer species. Buffer species are prey fishes of high abundance (e.g., fathead minnow) that dilute predation on less abundant prey species such as the Topeka shiner.

Figure 3 Dugout in the stream channel was termed "connected" to the stream in this study

Figure 4 Dugout disconnected from the stream

Figure 5 Disconnected dugouts with different distance and flood frequency scenarios



- Thirteen fish species first entered the new dugout in a frequently flooded zone in October 2005 and during several other floods through 2007. Another new dugout in an occasionally flooded zone was never connected to the stream, but brook sticklebacks were found in the spring of 2007.

Dugout placement options

This study relates to NRCS conservation practices in streams with and without Topeka shiners. Current recommendations for dugout placement relate only to dispersing livestock grazing in the basin. This study provides additional guidelines for lateral and longitudinal placement in the basin for fish conservation. The guidelines must be adapted to the landowner's needs, basin geographies, and with local knowledge. Knowledge of the flood prone width of streams is important but may not be available for some streams.

Fishes of intermittent streams have evolved survival strategies that include use of all aquatic habitats in the flood plain. If a landowner wishes to improve fish habitat in general, the results of this study suggest that dugouts can be compatible with stream fish resources if the dugouts have adequate habitat. Adequate means "okay," because dugouts are certainly not optimal, natural habitat for stream fishes, but this study showed that stream fishes reproduce and survive in dugouts.

Topeka shiners present

If Topeka shiners are present, none of the dugout placement options in the 100-year flood plain would guarantee that Topeka shiners would not be killed either by construction of connected dugouts or stranding in disconnected dugouts. The best dugout placement option to avoid Topeka shiner entry is of course outside of the 100-year flood plain.

The results of this study lead to recommendations for dugout placement that could enhance survival of Topeka shiners. If Topeka shiners are present and the objective is to enhance Topeka shiner habitat, dugouts constructed according to NRCS guidelines (must include connection to the ground water), should be placed in a frequently flooded zone, disconnected from and close to the stream channel (i.e., within the 50-ft riparian buffer zone).

Dugouts in the occasionally flooded or rarely flooded zone, disconnected from the stream, and distant from the stream are less likely to trap Topeka shiners than dugouts that are close and frequently flooded. However, fish trapped in dugouts distant from the stream must persist until the dugout and stream are reconnected by the rare flooding event and therefore are at higher risk.

Other stream fishes

To enhance habitat for other stream fishes, there are two placement options for new dugouts constructed according to NRCS plans, which must include connection to the ground water:

Option 1. Place the dugout in a frequently flooded zone and connected to the stream. The connected dugout will be a surrogate for a stream pool, which provides refuge during intermittence. However, connected dugouts may quickly fill with silt because water velocity is slower in the pond-like depression. A thick layer of silt is not good fish habitat, especially for spawning.

Option 2. Place the dugout in a frequently flooded zone and disconnected from the stream. The site can be near to or far from the stream within the frequently flooded zone (fig. 5). The disconnected site is an advantage because disconnected dugouts collect less silt and maintain depth and ground water inputs longer than connected dugouts and, thus, tend to be adequate off-channel fish habitats. The frequently flooded site provides some assurance that trapped fishes will have access to the stream every year or two.

To avoid or limit stream fish entry into dugouts, the dugouts should be placed outside of the flood plain or in the occasionally flooded zone. However, there is the rare occasion when a fish species somehow populates a dugout no matter where it is placed, as shown by the arrival of brook sticklebacks in a new dugout that has never been flooded.

Conclusions

Populations of Topeka shiners and other stream fishes may not be harmed and could be conserved when dugouts are constructed in very frequently flooded or frequently flooded zones anywhere in the longitudinal dimension of a stream such as Six Mile Creek. Dugouts can be a refuge during stream intermittence and a source of fish when the dugout is reconnected to the stream during flooding. The dugout should intersect with the ground water to promote fish survival. Topeka shiner use of off-channel habitat along Six Mile Creek agrees with observations made by other researchers studying streams in Iowa and Minnesota (Clark 2000; Dahle 2001; Hatch 2001).

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