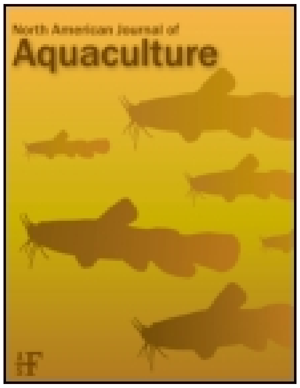

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Culture of Plains Topminnow in a Pond Constructed for Species Conservation

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COMMUNICATION

Culture of Plains Topminnow in a Pond Constructed for Species Conservation

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Abstract
The plains topminnow *Fundulus sciadicus* appears to be experiencing reductions in geographic range and local abundance, which has led to regional protection throughout its native range. Conservation of this species may require introductions to reestablish populations at known historic locations. Therefore, a pond was constructed during September 2007 to house a refuge population of plains topminnow in Nebraska. A total of 123 plains topminnow were stocked into the pond in two stocking events during 2008. Plains topminnow populations were sampled throughout 2008 and mark–recapture population estimates were conducted after reproductive events during 2009 and 2010 resulting in estimates of 9,844 ± 1,698 (mean ± SD) and 3,974 ± 452 plains topminnow, respectively. Mean fish weight was used as an estimate of pond biomass, which was 28.4 kg/ha in 2009 and 44.9 kg/ha in 2010. Reproduction was first observed in 2008 and in each following year, and a strong year-class was produced in 2009, which suggested there were factors that limited reproduction in the other 2 years. Extensive culture may be an effective way to rear plains topminnow and related species. However, more research is needed to determine factors that affect year-class strength and production.

Reintroduction is becoming an important tool in efforts to manage native fish (Archdeacon and Bonar 2009), creating a need to develop and maintain refuge populations as sources for rare fishes (Wagner et al. 2006). Despite the potential importance of captive propagation to management and conservation actions (Schultz and Bonar 2009), little is known about culture for most threatened or endangered fishes, especially compared with sport and baitfish species (Kline and Bonar 2009). Several nongame fish propagation strategies have been investigated, including rearing of Mohave tui chub *Gila bicolor mohavensis* (Archdeacon and Bonar 2009), suckermouth minnow *Phenacobius mirabilis* (Bestgen and Compton 2007), Yaqui topminnow *Poeciliopsis occidentalis sonoriensis* and Yaqui chub *G. purpurea* (Kline and Bonar 2009), and dusky darter *Perca sciera* (Labay et al. 2004) in laboratory settings. Pond production of small nongame fish has been investigated with baitfish, including Gulf killifish *Fundulus grandis* (Phelps et al. 2010) and fathead minnow *Pimephales promelas* (Clemment and Stone 2004).

Captive propagation may help augment populations of rare fishes where they have declined (Archdeacon and Bonar 2009). It also can serve as a useful tool in the reestablishment of extirpated populations at historic locations (Bestgen and Compton 2007; Kline and Bonar 2009). In addition, captive propagation of rare fishes has the potential to provide information about life history characteristics (Blinn et al. 1998; Gibson and Fries 2005) and improve the understanding of habitat requirements, growth, and reproduction (Billman et al. 2008).

The plains topminnow *F. sciadicus* is a small nongame fish that can reach 70 mm total length (Cross and Collins 1995; Pflieger 1997) and is commonly found in areas with dense aquatic vegetation and little to no flow (Rahel and Thel 2004). Spawning consists of one egg clutch per year, when between 30 and 50 eggs are deposited on vegetation between late April and early July with hatch occurring in approximately 14 d

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(Kaufmann and Lynch 1991; Cross and Collins 1995; Pflieger 1997). Declining water quality, habitat degradation, and introduction of nonnative fishes have caused other stream fishes of the Great Plains to decline in distribution and abundance (Haslouer et al. 2005) and are likely factors affecting plains topminnow populations (Rahel and Thel 2004).

Plains topminnow populations have declined across their native range (Rahel and Thel 2004; Haas 2005; Pasbrig 2010). It is presumed extirpated from Kansas and Iowa (Harlan et al. 1987; Haslouer et al. 2005; Pasbrig 2010). In South Dakota the plains topminnow is listed as threatened, and in Minnesota, Missouri, Colorado, Wyoming, and Nebraska it is listed as a species of special concern (Bailey and Allum 1962; Everhart and Seaman 1971; Brinkman 1994; Weitzel 2002). Recent sampling of 427 of the 618 historical plains topminnow sites in Nebraska, the state with the greatest number of historical sites, found the plains topminnow to be absent from more than 65% of sampled sites (Haas 2005; Pasbrig et al. 2012).

Because of the observed declines across most of its range, the plains topminnow is being considered for federal protection (Pasbrig 2010). Reintroduction of plains topminnow may be necessary to reestablish or maintain populations at historical locations in Nebraska and elsewhere. The objectives of this project were to (1) establish a population of plains topminnow in a constructed pond and (2) describe production capabilities of plains topminnow in a constructed pond.

METHODS

Pond construction.—During September 2007, a pond was constructed to support a refuge population of plains topminnow at the Sacramento–Wilcox Wildlife Management Area in Phelps County, south-central Nebraska. The pond is approximately 0.3 ha with a maximum depth of about 3 m. Clay soils from depths of 1.0–1.5 m were set aside and used to cover approximately 8,700 kg of bentonite added to the substrate to assist with sealing the pond. An irrigation pipe connected to a groundwater well was used to fill the pond and was used to adjust water levels manually. Aquatic vegetation was introduced in 2008 and was augmented throughout 2009. Introduced vegetation included a single unknown species of *Typha* spp., *Potamogeton* spp., *Lemna* spp., *Physcomitrium* spp., and *Scirpus* spp.

A total of 68 plains topminnow were collected with a fine-mesh seine (6.4 × 1.2 m, 6.4-mm mesh) from Dry Creek, near Calamus, Nebraska, in April 2008 and introduced into the constructed pond. Specimens introduced measured between 45 and 62 mm total length (TL; mean ± SE = 52.1 ± 0.5 mm). An additional 55 unmeasured plains topminnow were collected at Dry Creek in October 2008 and introduced into the pond. In each case, plains topminnow were transported in aerated water (approximately 15°C) from the collection site. Temperatures at the time of collection were between 12°C and 15°C at the collection site and at the constructed pond.

Population monitoring.—Monthly sampling of the plains topminnow populations began in October 2008 in an attempt to determine whether reproduction had occurred. During each sampling effort, five seine (6.4 × 1.2 m, 6.4-mm mesh) pulls were performed and the number of fish and TL (mm) of each was recorded. Fish were assigned to particular year-classes based upon modal length-frequency analysis that was supported by age estimation (DeVries and Frie 1996). A total of 51 scale samples were taken and read using a stereoscope to estimate the age structure within the pond in October 2009 ($n = 35$) and September 2010 ($n = 16$).

During fall of 2009 and 2010 population estimates of cultured plains topminnow were completed using a modified Lincoln–Peterson model (Ricker 1975):

$$N = [(M + 1)(C + 1)/(R + 1)] - 1,$$

where N is the population estimate, M is the total number of marked fish at the first visit, C is the total number of fish investigated for marks at the second visit, and R is the number of recaptures at the time of the second visit. Plains topminnow were captured by seine (6.4 × 1.2 m, 6.4-mm mesh) until a minimum of 1,000 individuals were marked. Plains topminnow were marked using red (2009) or yellow (2010) visible implant elastomer (VIE) tags, which were injected posterior to the dorsal fin. A total of 1,045 fish were marked in August 2009 and 1,051 were investigated for marks on the second visit 7 d later. In September 2010, 1,014 fish were marked and 1,021 were investigated for marks 7 d later. A subset of 100 fish were measured for TL (mm) during the second sample of both years. Juvenile topminnow less than 30 mm TL were excluded from the population estimate, because of potential high mortality from marking efforts.

Marking and handling mortalities were estimated in separate mark–retention studies in 2009 and 2010. Each year 40 fish were collected and measured for TL (mm) and divided into two groups. Groups of 20 fish were marked with VIE tags and handled similar to the methods used for population estimates, while the other 20 were handled and measured without being marked before placement into separate 1-m^3 holding cages anchored in the center of the pond. Fish were examined for mark retention and mortality at 1, 7, and 14 d after marking.

In 2009, one group of 50 plains topminnow was weighed to determine mean individual fish weight. In 2010, 10 groups of 10 fish each were weighed to determine mean individual fish weight. In each case, fish were weighed to the nearest 0.1 g using an Ohaus ES 6R digital scale. Mean individual fish weight was used each year to calculate biomass of plains topminnow in the pond. All mean values are reported with corresponding SE.

RESULTS

Evidence of reproduction was first apparent in October 2008 as fish sampled were smaller (minimum TL = 29 mm) when

TABLE 1. Sampling data for plains topminnow seined from a 0.3-ha production pond at Sacramento–Wilcox Wildlife Management Area, Phelps County, Nebraska, during 2008, 2009, and 2010. TL = total length.

Date	Number (*n*)	Mean TL (mm)	Minimum TL (mm)	Maximum TL (mm)	Mean weight (g)	Biomass (kg/ha)	Population estimate (Mean *N* ± SD)
Apr 2008	68[a]	52.1	45	62			
Oct 2008	55[a]						
Oct 2008	85	49.8	29	72			
Mar 2009	9	50.9	43	67			
Apr 2009	40	48.8	35	64			
Jul 2009	28	42.9	18	79			
Aug 2009	1,100[b]	37.3	21	53	0.8[c]	28.4	
Aug 2009	1,051[d]						9,844 ± 1,698
Sep 2009	40	43.6	34	54			
Oct 2009	35	43.8	30	67			
Nov 2009	50	41.2	32	51			
Sep 2010	1,014[b]	61.2	38	71	3.4 ± 0.3[e]	44.9	
Sep 2010	1,021[d]						3,974 ± 452

[a]Stocked fish.
[b]Number of fish marked.
[c]One sample of 50 total fish.
[d]Number of fish investigated for marks in second visit.
[e]Mean ± SE, 10 groups of 10 fish each weighed.

compared with fish initially stocked in April 2008 (minimum TL = 45 mm) (Table 1). A large year-class was produced in 2009 as numerous age-0 fish were captured in seining efforts and with spawning likely to have occurred before July as minimum fish TL was smaller than in previous months (Table 1; Figure 1). In 2009, age estimation based on scale samples supported age-classes assigned to modal groups in which the majority of captured fish belonged to age 0, and few age-1 individuals were captured (Figure 1). Growth continued for the cohort that was spawned in 2009 and the sample in September 2010 was larger on average than those sampled in 2009 (Table 1; Figure 1). However, these now age-1 and age-2 individuals appeared to have produced few offspring, and few age-0 fish were captured in 2010 (Table 1; Figure 1). Age estimation again supported age-classes assigned to modal groups in 2010 (Figure 1).

Mark retention was 100% in 2009 and 2010, while mortality of marked fish was 5% in 2009 and 0% in 2010. Mortality of individuals handled without marking was 5% and 0% in 2009 and 2010, respectively. The estimated population of plains topminnow in 2009 was 9,844 ± 1,698 individuals and in 2010, the population of plains topminnow was estimated to be 3,974 ± 452 with no adjustment for marking mortality (Table 1). Because the funding agency desired that plains topminnow be stocked, a total of 2,308 plains topminnow were previously removed from the pond in October 2009 for introductions in Nebraska.

Plains topminnow collected in 2009 had a mean mass of 0.8 g for the group of 50 fish batch-measured (Table 1). Plains topminnow collected in 2010 were much larger with a mean mass of 3.4 ± 0.3 g (Table 1). Total biomass of plains topminnow

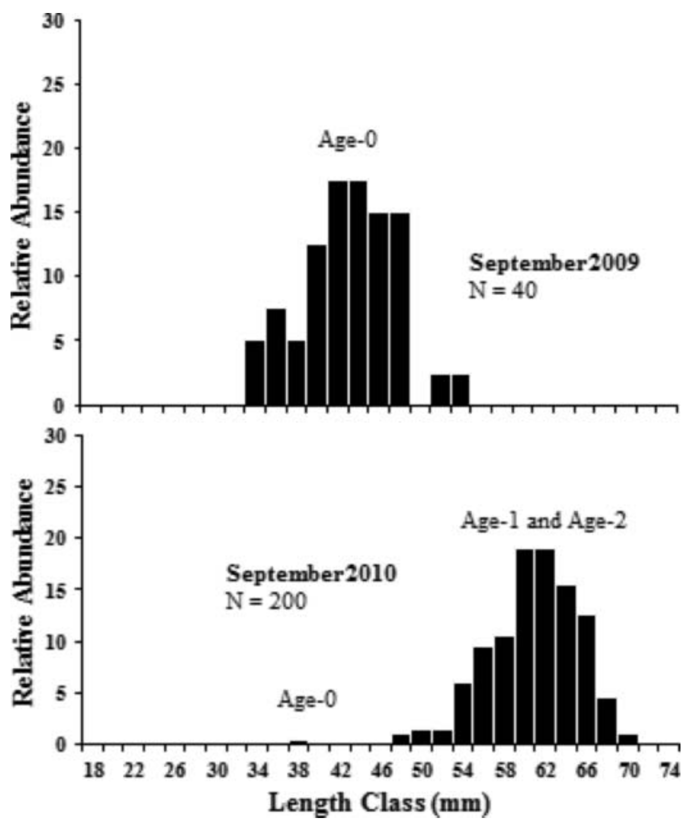

FIGURE 1. Length-frequency (total length) of plains topminnow sampled in September 2009 and September 2010 from a 0.3-ha pond, indicating the length-groups of fish caught and how ages were assigned, at the Sacramento–Wilcox Wildlife Management Area broodstock pond, Phelps County, Nebraska.

in the constructed pond in 2009 and 2010 was calculated to be 28.4 kg/ha and 44.9 kg/ha, respectively (Table 1).

DISCUSSION

The constructed pond did not consistently produce strong year-classes of plains topminnow in the 3 years of monitoring. In 2008, the pond first produced juvenile topminnow and in 2009 the pond produced a large group of age-0 fish; however, few young fish were produced in 2010. Initial recruitment in 2008 may have been limited because of slow development of the vegetative community, which would limit spawning habitat (Kaufmann and Lynch 1991). Additionally, because the fish were stocked in late April, spawning development and behavior could have been interrupted (Kaufmann and Lynch 1991; Cross and Collins 1995; Pflieger 1997). Growth continued for the cohort that was spawned in 2009, but these fish appeared to have produced few offspring resulting in the diminished population in 2010. A likely explanation for reduced recruitment in 2010 was poor management of water levels in the pond that year. The pond had not sealed, and water levels dropped by approximately 0.25 m per month (Pasbrig 2010) and required manual adjustment. In 2010, water augmentation did not begin until May, after the reported spawning period for plains topminnow (Kaufmann and Lynch 1991). If eggs were fertilized and deposited on shallow macrophytes, a decrease in water level that was not corrected may have reduced recruitment.

More than an 80-fold increase in population size was observed in the year after the initial introduction of plains topminnow individuals, which is similar to that observed for Gulf killifish cultured in plastic ponds in Florida (Phelps et al. 2010). The results of the current study are also similar to the success achieved with Yaqui chub and Yaqui topminnow that were found to have high recruitment in wading pools (Kline and Bonar 2009). The observed population decrease in 2010 is partially due to the removal of 2,308 individuals in October 2009 that were stocked in Nebraska. The decrease in 2010 population numbers is of some concern as potentially the pond reached carrying capacity or lacked adequate conditions for consistent recruitment.

Despite the decrease in the number of fish in the pond in 2010, the estimated biomass of plains topminnow was greater in 2010 than in 2009. In 2010, the biomass was close to double that of fathead minnow cultured in South Dakota wetlands by Payer and Scalet (1978). The plains topminnow biomass was found to be much lower in the constructed pond than that of Gulf killifish, which achieved biomass between 820 and 1,333 kg/ha in saline groundwater (Phelps et al. 2010). The observed decrease of plains topminnow is therefore more likely to be the result of reduced recruitment than a limit on carrying capacity.

Plains topminnow were handled extensively throughout this study with little apparent mortality (maximum estimated mortality of fish was found to be 5% when fish were captured with a seine). The fish marked in 2009 were smaller on average than those in 2010, which probably resulted in the higher mortality observed with marking and handling. Transportation of these fish will probably result in low mortality as plains topminnow appear to be tolerant of handling and marking (Pasbrig 2010) and are tolerant of a wide range of water conditions (Brinkman 1994).

Plains topminnow are adapted to survival in shallow, isolated pools and have been observed to tolerate wide ranges of environmental conditions including high and low temperatures and low dissolved oxygen (Brinkman 1994). Physiological and morphological adaptations allow plains topminnow to occupy habitats in the environment that are unsuitable for other Great Plains fish species (Brinkman 1994; Rahel and Thel 2004). Thus, plains topminnow would probably succeed in existing ponds that are of marginal use to hatchery managers for other species.

Extensive culture of fishes has served as a useful tool in the propagation of baitfish and sport fish (Payer and Scalet 1978), but has yet to be fully implemented in the management of rare nongame fishes. The use of constructed ponds for propagation of fish is economically efficient, because minimal maintenance is required. The construction of a broodstock pond has served as an effective way to establish a population of plains topminnow, although consistency of production was variable. Similar methods might be favorable in the natural propagation of other related species. Aquatic vegetation should be available during the initial stocking time to provide plains topminnow with favorable spawning habitat, foraging grounds, and protection from terrestrial predators (Kaufmann and Lynch 1991; Brinkman 1994; Weitzel 2002; Rahel and Thel 2004). In addition, pond water levels should be maintained so that reproduction is not impeded by exposure of eggs. In our pond, vegetation had become overabundant by 2011 and impeded the capture of plains topminnow, so methods of macrophyte control may be necessary in the near future. Although plains topminnow have been successfully cultured within this pond, further research is needed to understand the factors that affect recruitment and year-class strength so that production can be optimized each year.

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REFERENCES

Archdeacon, T. P., and S. A. Bonar. 2009. Captive breeding of endangered Mohave tui chub. North American Journal of Aquaculture 71:360–362.

Bailey, R. M., and M. O. Allum. 1962. Fishes of South Dakota. Museum of Zoology, University of Michigan, Miscellaneous Publication 119, Ann Arbor.

Bestgen, K. R., and R. I. Compton. 2007. Reproduction and culture of suckermouth minnow. North American Journal of Aquaculture 69:345–350.

Billman, E. J., E. J. Wagner, and R. E. Arndt. 2008. Reproductive ecology and spawning substrate preference of the northern leatherside chub. North American Journal of Aquaculture 70:273–280.

Blinn, D. W., J. White, T. Pradetto, and J. O'Brien. 1998. Reproductive ecology and growth of a captive population of Little Colorado spinedace (*Lepidomeda vittata:* Cyprinidae). Copeia 1998:1010–1015.

Brinkman, M. A. 1994. Observations of the plains topminnow in South Dakota. Prairie Naturalist 26:307–308.

Clemment, T., and N. Stone. 2004. Collection, removal, and quantification of eggs produced by rosy red fathead minnows in outdoor pools. North American Journal of Aquaculture 66:75–80.

Cross, F. B., and J. T. Collins. 1995. Fishes in Kansas. University of Kansas Natural History Museum, Public Education Series 14, Lawrence.

DeVries, D. R., and R. V. Frie. 1996. Determination of age and growth. Pages 483–512 *in* B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Everhart, W. H., and W. R. Seaman. 1971. Fishes of Colorado. Colorado Game, Fish, and Parks Division, Denver.

Gibson, J. R., and J. N. Fries. 2005. Culture studies of the Devils River minnow. North American Journal of Aquaculture 67:294–303.

Haas, J. D. 2005. Evaluation of the impacts of the introduced western mosquitofish, *Gambusia affinis*, on native plains topminnow, *Fundulus sciadicus*, in Nebraska. Master's thesis. University of Nebraska, Kearney.

Harlan, J. R., E. B. Speaker, and J. Mayhew. 1987. Iowa fish and fishing. Iowa Department of Natural Resources, Des Moines.

Haslouer, S. G., M. E. Eberle, D. R. Edds, K. B. Gido, C. S. Mammoliti, J. R. Triplett, J. T. Collins, D. A. Distler, D. G. Huggins, and W. J. Stark. 2005. Current status of native fish species in Kansas. Transactions of the Kansas Academy of Science 108:32–46.

Kaufmann, S. A., and J. D. Lynch. 1991. Courtship, eggs, and development of the plains topminnow in Nebraska (Actinopterygii: Fundulidae). Prairie Naturalist 23:41–45.

Kline, J. S., and S. A. Bonar. 2009. Captive breeding of endangered Yaqui topminnow and Yaqui chub for recovery purposes. North American Journal of Aquaculture 71:73–78.

Labay, A. A., R. W. Standage, and T. M. Brandt. 2004. Selected methods for dusky darter captive propagation. North American Journal of Aquaculture 66:146–152.

Pasbrig, C. A. 2010. Reductions in range-wide distribution of plains topminnow, *Fundulus sciadicus,* and production of a broodstock pond. Master's thesis. University of Nebraska, Kearney.

Pasbrig, C. A., K. D. Koupal, S. Schainost, and W. W. Hoback. 2012. Changes in range-wide distribution of plains topminnow *Fundulus sciadicus*. Endangered Species Research 16:235–247.

Payer, R. D., and C. G. Scalet. 1978. Population and production estimates of fathead minnows in a South Dakota prairie wetland. Progressive Fish-Culturist 40:63–66.

Pflieger, W. L. 1997. The fishes of Missouri. Missouri Department of Conservation, Jefferson City.

Phelps, R. P., W. H. Daniels, N. R. Sansing, and T. W. Brown. 2010. Production of gulf killifish in the black belt region of Alabama using saline groundwater. North American Journal of Aquaculture 72:219–224.

Rahel, F. J., and L. A. Thel. 2004. Plains topminnow (*Fundulus sciadicus*): a technical conservation assessment. U.S. Department of Agriculture Forest Service, Rocky Mountain Region, Golden, Colorado. Available: www.fs.fed.us/r2/projects/scp/assessments/plainstopminnow.pdf. (September 2009).

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 191.

Schultz, A. A., and S. A. Bonar. 2009. Growth and survival of larval and juvenile Gila chub at different temperatures. North American Journal of Aquaculture 71:1–5.

Wagner, E. J., E. J. Billman, and R. Arndt. 2006. Evaluation of substrate type and density as factors in optimizing growth of least chub. North American Journal of Aquaculture 68:306–312.

Weitzel, D. L. 2002. Conservation and status assessments for the finescale dace (*Phoxinus neogaeus*), pearl dace (*Margariscus margarita*), and plains topminnow (*Fundulus sciadicus*): rare native fish species of the Niobrara and Platte basins, Wyoming. Wyoming Game and Fish Department, Cheyenne.