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# THE DECLINE OF THE OZARK HELLBENDER (*CRYPTOBRANCHUS ALLEGANIENSIS BISHOPI*) IN THE SPRING RIVER, ARKANSAS, USA

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*Abstract*.**—Between August 2003 and December 2004 we completed a survey for Ozark Hellbenders (*Cryptobranchus alleganiensis bishopi*) in the Spring River (Fulton and Sharp counties, Arkansas, USA), beginning at Mammoth Spring and continuing downstream 27 km to the Arkansas Game and Fish Commission's Hardy Beach Access. We spent 74 person-hours searching 33 locations, which were chosen based on past records of occurrence (four localities) or the presence of potential *C. a. bishopi* habitat. We captured 12 Ozark Hellbenders at three of the four known local population sites. All 12 hellbenders were large (minimum 479 mm total length). Furthermore, data compiled from 1971 to 2004 illustrated a substantial temporal shift in size classes toward larger animals, a characteristic indicative of declining recruitment. Based upon these findings, the Ozark Hellbender appears to be at risk of extirpation from the Spring River.**

*Key Words.*—amphibian decline; *Cryptobranchus*; Hellbender; Spring River

## INTRODUCTION

The Spring River (Fulton and Sharp counties, Arkansas, USA) is continuously recharged by the ninth largest spring in the world (the second largest spring in the Ozark Mountains), which discharges an average of 33,993 $m^3$ of water per hour (Shepherd 1984). The Arkansas Pollution Control and Ecology Commission (APCEC) has designated the river and its tributaries as Extraordinary Resource Waters, indicating that the drainage is an invaluable resource for recreational activities, as well as for science (Regulation 2: regulation establishing water quality standards for surface waters of the state of Arkansas, 22 July 2011). Furthermore, the APCEC also designated the Spring River as an Ecologically Sensitive Waterbody, signifying that the river supports rare, threatened, endangered, or endemic species.

The Ozark Hellbenders of the Spring River have been one of the most studied populations throughout the Ozark Mountains and were recently listed as endangered, along with all other populations of *Cryptobranchus alleganiensis bishopi*, under the Endangered Species Act (U.S. Fish and Wildlife Service 2011). Hellbenders were first reported from the Spring River by Black and Dellinger (1938). Grobman (1943) first recognized two lineages of hellbenders, and separated the Eastern Hellbender (*C. alleganiensis*) from the Ozark Hellbender (*C. bishopi*); he speculated that the Spring River hellbender population was of the Ozark variety. Firschein (1951) reported that the Spring River hellbender population was *C. bishopi*, but did not examine any specimens. The earliest museum record of the Ozark Hellbender from the Spring River is from 1958 (Smithsonian, National Museum of Natural History, catalog number 544564). Dundee and Dundee (1965) conducted a systematic investigation of hellbenders and assigned the Spring River population to the species *C. bishopi*. However, Dundee (1971) later recommended that the rank should be a subspecies (*C. a. bishopi*), rather than a species (*C. bishopi*). The distinctiveness of the Spring River Ozark Hellbender population has been the focus of much research, and with conflicting results. Taketa and Nickerson (1973) compared the hemoglobin of hellbenders from the Spring River with that of other populations and found no differences, indicating genetic similarity between the two subspecies; whereas, Merkle et al. (1977) examined the Spring River hellbender population as part of a range-wide study and reported low within-river diversity, but noted that the *bishopi* populations were distinguishable from the other populations of *C. a. alleganiensis* studied based on morphological variation. This finding was further substantiated by mitochondrial DNA analysis, which noted the distinctiveness of the Spring River population from other hellbender populations (Routman 1993). Moreover, mitochondrial DNA analysis by Routman et al. (1994) found that hellbenders from the Spring River are most closely united with hellbenders from the North Fork of the White River, as opposed to hellbenders from the Eleven Point or Current rivers, as would be expected based on geographic proximity and connectivity between river systems.

The Spring River population of hellbenders breeds later than other populations of Ozark Hellbenders.

Baker (1963) reported that hellbenders collected from Spring River had enlarged testes and were full of mature sperm in December. Dundee and Dundee (1965) reported that the greatest ovum diameter was found in late October, indicating a late breeding season, possibly due to the stable spring water temperatures. Peterson (1985) also found gravid females and reproductive males from the Spring River in December. Peterson et al. (1989a) validated the unique breeding time and reported finding egg clutches during January and February.

Although Baker (1963) and Nickerson and Mays (1973) noted a large population of Ozark Hellbenders inhabiting the upper reaches of the Spring River, Peterson et al. (1988) were the first to examine the population size and structure within the Spring River. Using data collected between May 1980 and September 1982, they estimated the local population size at their collection site 1 to be 442 individuals and at their collection site 2 to be 81. Trauth et al. (1992, 1993) conducted status/distributional work and reported a diminished capture rate at Peterson et al. (1988) collection site 1 and a total absence of Ozark Hellbenders at collection site 2. Trauth et al. (1992) also reported capturing Ozark Hellbenders at a site 0.46 km downstream from the springhead (their access site 1), along with two anecdotal reports of Ozark Hellbenders at an additional site (their access site 7). The first verified records of Ozark Hellbenders from Trauth et al. (1992) access site 1 were from 1978 (Chris L. Peterson, unpubl. data), whereas access site 7 had no previous records of Ozark Hellbenders.

Trauth et al. (2002) documented one Ozark Hellbender caught above the Arkansas Game and Fish Commission's Bayou Access (Trauth et al. [1992] access site 7) that exhibited epidermal papillomas, the first published case of abnormalities not intrinsic to hellbender natural history. Harshbarger and Trauth (2002) subsequently upgraded the epidermal papillomas reported in Trauth et al. (2002) to squamous cell carcinoma upon further examination of the tissue during necropsy. Wheeler et al. (2002) reported on abnormalities found across the entire range of the Ozark Hellbender. Hiler et al. (2005) examined abnormality type and rate in Spring River museum specimens collected during the 1970s and in Ozark Hellbenders from the Spring River caught during the 2003–2004 field seasons. They found a 12.5% abnormality rate in the 1970s museum specimens and a 90% abnormality rate in hellbenders they captured. These abnormalities included tumors, lesions, fungal infections, necrotic limbs, digital abnormalities, and missing limbs. Nickerson and Mays (1973) citing personal communication with Guy Johnson, reported that the commonly encountered leeches (*Placobdella cryptobranchii*) caused lesions at the point of attachment and sometimes formed large sores. Its presence was confirmed in the Spring River by Moser et al. (2008).

Overall, the Ozark Hellbender population in the Spring River has received much attention; however, there have been few concerted efforts for the conservation of this species in the Spring River. This may be due, in part, to a lack of literature directly addressing the decline quantitatively. The primary objective of our study is to document the population decline of the Ozark Hellbender in the Spring River. This is accomplished through the completion of a survey of potential hellbender habitat, and the comparison of several data sets, which begin in 1971 and end in 2004.

## MATERIALS AND METHODS

The springhead of the Spring River is located approximately 0.15 km south of the Arkansas/Missouri state line. We chose study sites between the springhead and the Arkansas Game and Fish Commission's Hardy Beach access point in Hardy, Arkansas. We searched for Ozark Hellbenders at 33 localities that were selected based on the presence of marginal to good hellbender habitat (Nickerson and Mays 1973). We recorded a global positioning system (GPS) point at each site and noted the approximate area of potential habitat. We recorded all GPS points in North American Datum (NAD) 27, latitude / longitude format.

We located Ozark Hellbenders with standard rock-flipping techniques performed while wearing scuba or skin diving equipment (Nickerson and Mays 1973). Our survey efforts began August 2003 and concluded December 2004. Following captures, we collected standard data that included: total length (TL), snout-vent length (SVL), mass, and sex. We also implanted an Avid® encrypted passive integrated transponder (PIT) tag (Avid Identification Systems, Inc., Norco, California, USA) in the caudal musculature for unique salamander identification. We searched survey sites until approximately 75% of the potential habitat was covered and calculated the time spent at each site in total person-hours (phr). We searched sites multiple times that contained previously verified records of Ozark Hellbenders. Data collected on hellbenders during these searches formed our 2000 era data set.

Our 1970 era data set represents data (TL) gathered from 45 Ozark Hellbenders accessioned in the Milwaukee Public Museum (Milwaukee, Wisconsin) that were collected from the Spring River between 1971 and 1975. Our 1980 era data set was created by data provided by Dr. Chris L. Peterson, and it represents data on 442 individuals captured between 1978 and 1986. This sample included 370 individuals used in Peterson et al. (1988), four hellbenders caught between May 1980 and September 1982 that were not included in Peterson et al. (1988), 67 individuals captured on 29 October

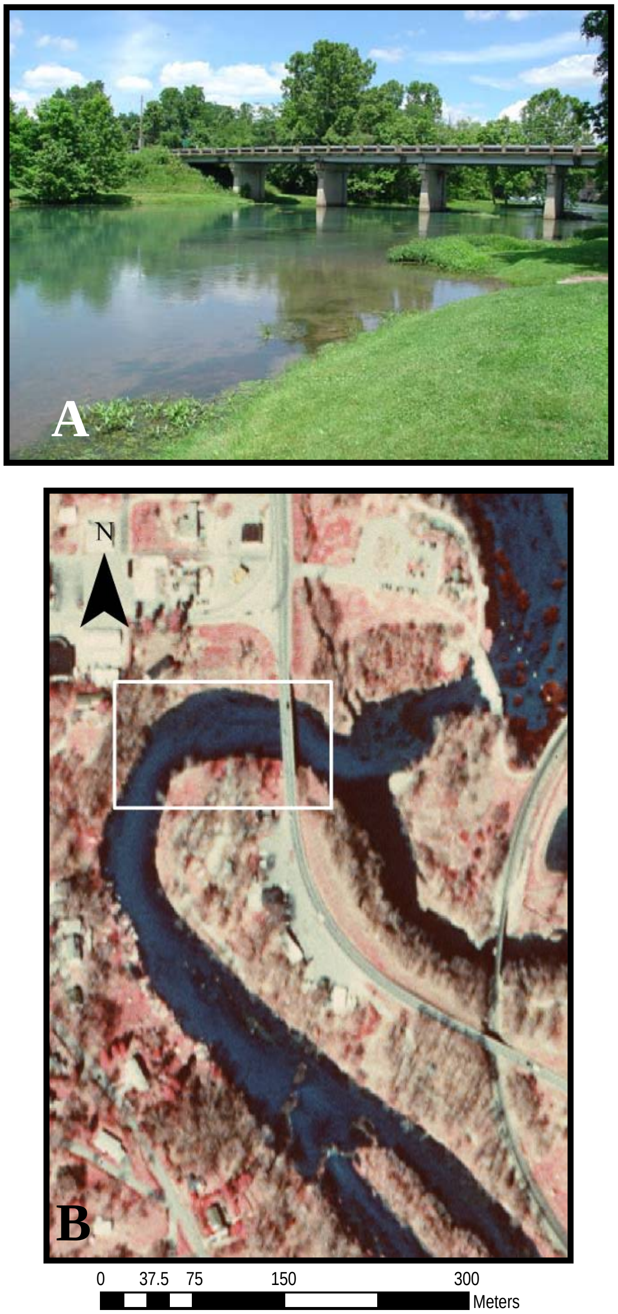


**FIGURE 1.** **A.** View of Trauth et al. (1992) access site 1, positioned directly downstream of the Arkansas State Highway 63 bridge. (Photographed by Waylon Hiler). **B**. Aerial photograph of Trauth et al. (1992) access site 1, white box represents the approximate area of habitat searched. (Photograph from Arkansas' Official GIS Platform)

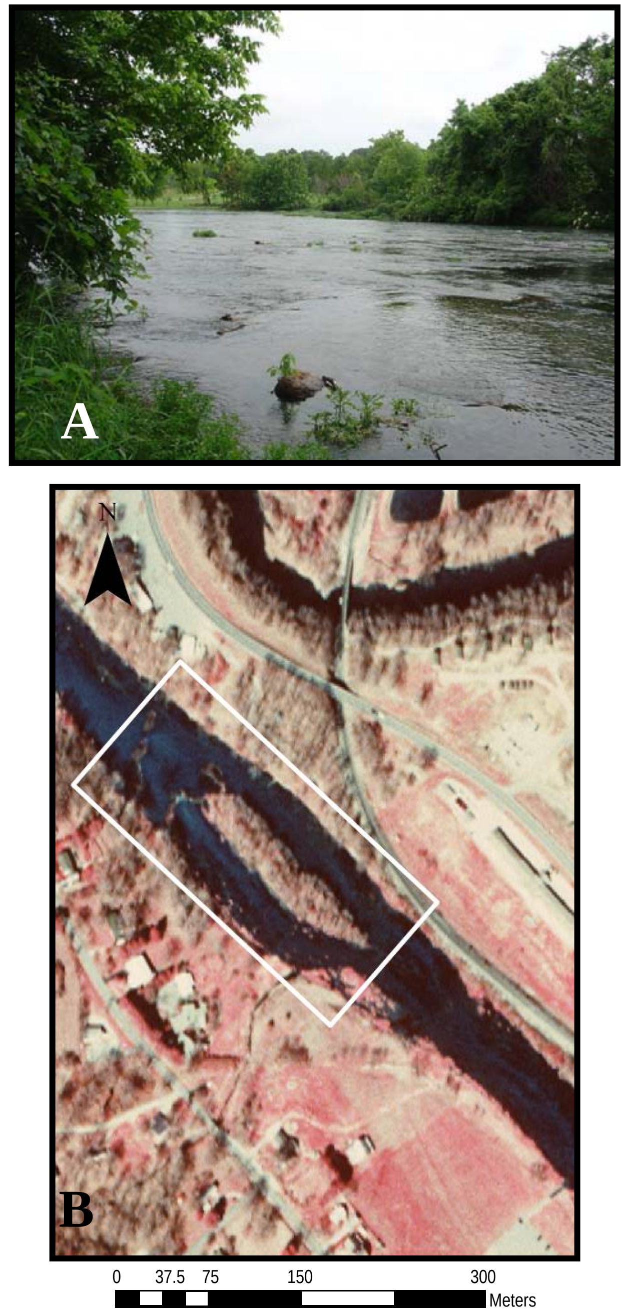


**FIGURE 2.** **A.** View of Peterson et al. (1988) collection site 2, facing downstream along the left bank of the east channel. (Photographed by Waylon Hiler). **B**. Aerial photograph of Peterson et al. (1988) collection site 2; white-outlined box represents the approximate area of habitat searched. (Photograph from Arkansas' Official GIS Platform)

1978, and one individual captured on 19 July 1986. One of us (SET) provided our 1990 era data set, which represents data for 49 Ozark hellbenders captured between 1991 and 1996. We created size frequency histograms using Ozark Hellbender TLs to create a temporal comparison of Spring River hellbenders from the 1970s, 1980s, 1990s, and early 2000's. We used a non-parametric Kruskal-Wallis test to test for significant differences among data sets from the Spring River. The four sites on the Spring River known to be inhabited by Ozark Hellbenders are as follows (upstream to downstream and identified by first appearance in the literature): (1) Trauth et al. (1992) access site 1 (Fig. 1), located approximately 0.46 km downstream below the

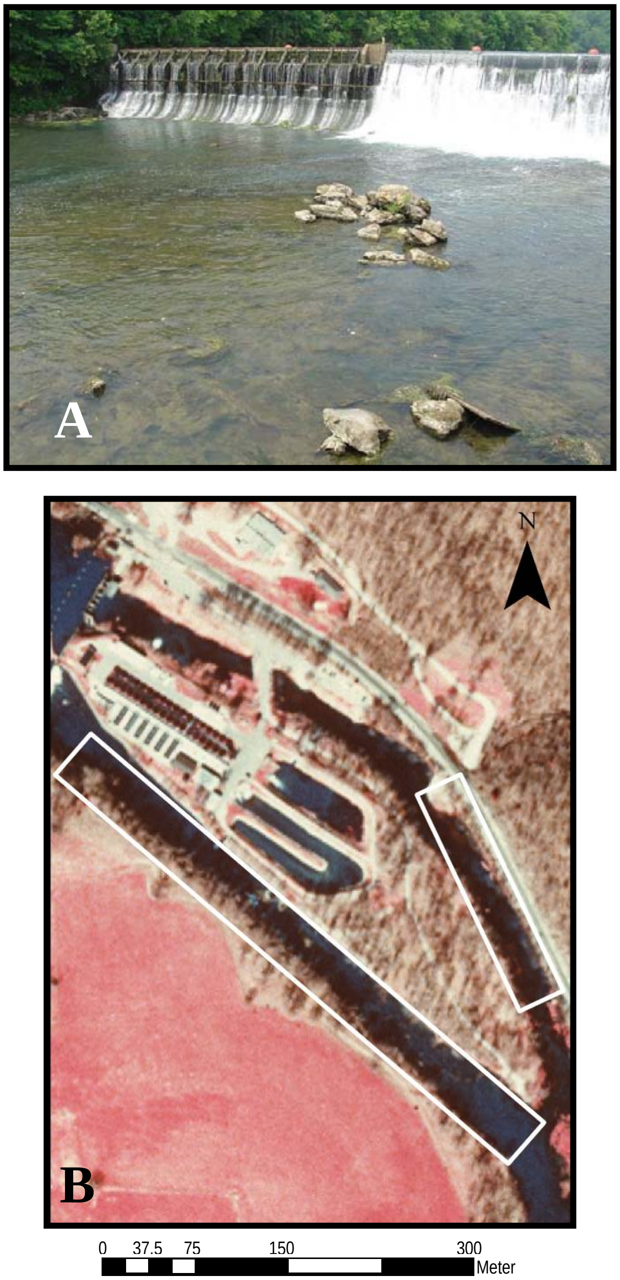


**FIGURE 3. A.** View of Peterson et al. (1988) collection site 1, right channel. (Photographed by Waylon Hiler) **B.** Aerial photograph of Peterson et al. (1988) collection site 1; white-outlined boxes represent the approximate area of habitat searched. (Photograph from Arkansas' Official GIS Platform)

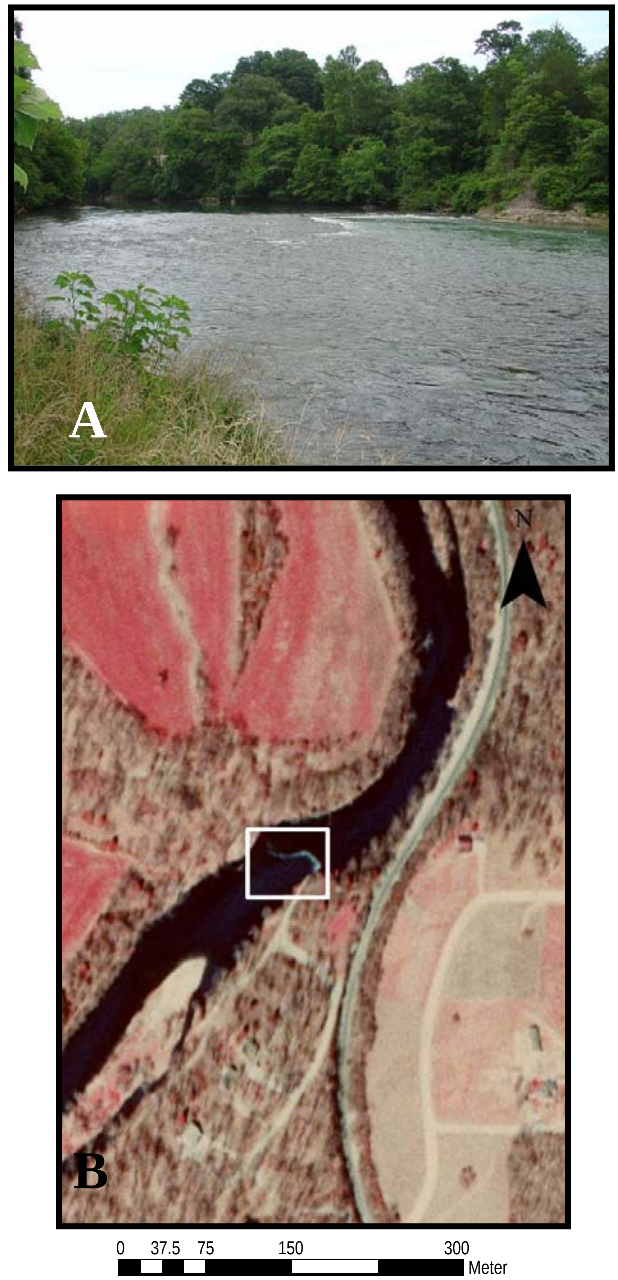


**FIGURE 4. A.** View of Trauth et al. (1992) access site 7, facing upstream. (Photographed by Waylon Hiler) **B**. Aerial photograph of Trauth et al. (1992) access site 7; white-outlined box represents the approximate area of habitat searched. (Photograph from Arkansas' Official GIS Platform)

springhead; (2) Peterson et al. (1988) collection site 2 (Fig. 2), located approximately 1.0 km downstream of the springhead; (3) Peterson et al. (1988) collection site 1 (Fig. 3), located approximately 7 km downstream of the springhead; and (4) Trauth et al. (1992) access site 7 (Fig. 4), located approximately 9.6 km downstream of the springhead. A complete list of surveyed Spring River sites, including detailed descriptions of the physical habitat, is available upon request from the authors.

## RESULTS

We spent 74 phr searching 33 sites on the Spring River. We spent 10.83 phr searching at Trauth et al. (1992) access site 1 and caught three Ozark Hellbenders,

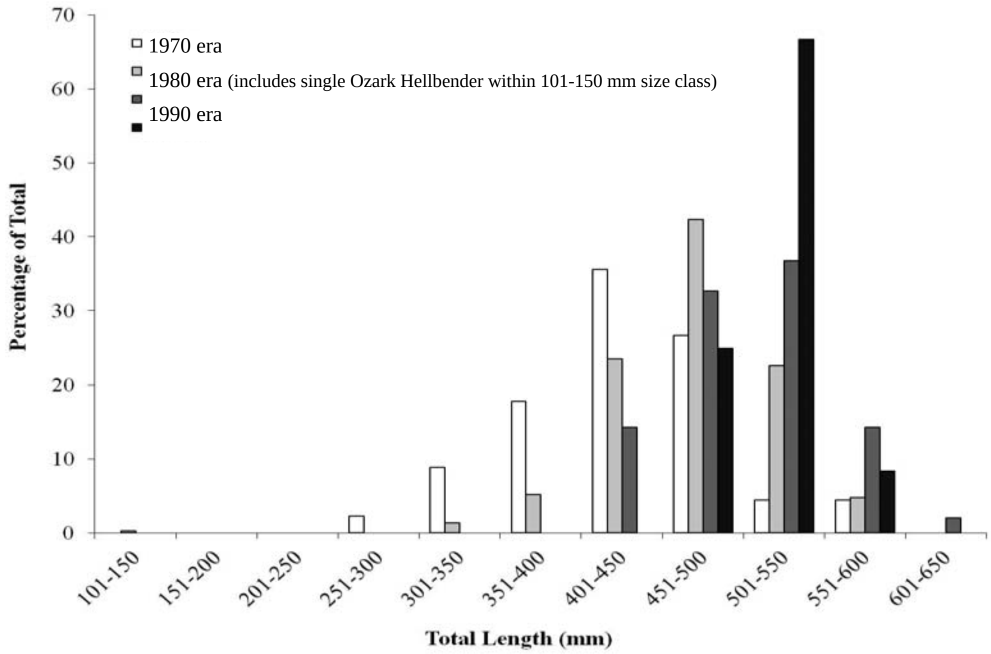


**FIGURE 5.** Size frequencies of Ozark Hellbenders captured from the Spring River between 1971 and 2004. 1970 era data collected from 1971–1975 (*n* = 45); 1980 era data collected from 1978–1986 (*n* = 442); 1990 era data collected from 1991–1996 (*n* = 49); and 2000 era data collected from 2003–2004 (*n* = 12).

we searched 17.75 phr at Peterson et al. (1988) collection site 1 and caught eight Ozark Hellbenders, and we spent 5.5 phr searching at Trauth et al. (1992) access site 7 and caught one Ozark Hellbender. We did not capture any Ozark Hellbenders at Peterson et al. (1988) collection site 2, which we spent 6 phr searching. A female Ozark Hellbender captured at Trauth et al. (1992) access site 1 exhibited multiple epidermal papillomas and died during transport to the laboratory (Hiler et al. 2005). We found the Ozark Hellbender caught at Trauth et al. (1992) access site 7 in atypical hellbender habitat, drifting amongst small woody debris in a small backwater pool and barely alive. There was a large gash on the animal's dorsum, which had been invaded by fungus (Hiler et al. 2005). The animal died as data were being collected.

We examined 45 specimens collected from the Spring River between 1971 and 1975, which are currently housed at the Milwaukee Public Museum. Data collected between 1978 and 1986 were available for 442 Spring River Ozark Hellbenders (Chris L. Peterson, unpubl. data), and data from the 1990 era were available for 49 Spring River hellbenders (Stanley E. Trauth, unpubl. data). When frequency of salamanders is represented by total length, the Spring River data sets illustrate a temporal shift in hellbender size frequencies toward larger animals (Fig. 5). There were significant differences among size distributions ($H = 51.63$, df = 3, $P < 0.001$,; 1970 era n = 45, median = 441 mm, $Z = -5.10$; 1980 era n = 442, median = 471 mm, $Z = -0.75$; 1990 era n = 49, median = 510 mm, $Z = 4.16$; 2000 era n = 12, median = 521 mm, $Z = 3.48$).

## DISCUSSION

The data gathered from each survey site indicated that few Ozark Hellbenders currently exist in the Spring River relative to the past. Only two locations support detectable levels of hellbenders, and Trauth et al. (1992) access site 7 only produced one individual in a morbid state and there is little suitable habitat in the immediate vicinity. Furthermore, based on our observations, the local population densities at Trauth et al. (1992) access site 1 and Peterson et al. (1988) collection site 1 were dramatically lower than reported by Peterson et al. (1989b), Chris L. Peterson (unpubl. data), and a previous survey by one of us (SET, unpubl. data). Comparison of size frequency distributions of Ozark Hellbenders captured in the Spring River from the early 1970s through the mid 1990s to the distribution of hellbenders collected during the early 2000s suggest an aging population with recruitment steadily declining since at least 1971. Furthermore, the remnant population in the Spring River may represent the final stage of hellbender extirpation from the river. Our assessment of the Ozark Hellbender population decline in the Spring River, made by comparing size frequencies, is substantiated by similar studies that have used similar methodology to evaluate ecological status or document declines in other populations of hellbenders (Nickerson et al. 2002; Wheeler et al. 2003; Burgmeier et al. 2011).

The two APCEC classifications for the Spring River (recreational use and ecological sensitivity) point to the potential contradictory management practices for the Spring River. The level of environmental stress created by large numbers of boaters, fishermen, and other recreationists is of concern and are factors associated with the decline of other *C. a. bishopi* populations (Max Nickerson et al., unpubl. report). These activities should also be considered contributing factors of the Spring River hellbender decline. However, recreational activities produce significant tourist and tax revenues for the surrounding communities, potentially creating opposition to conservation efforts that could interfere with revenue generation. As long as anthropogenic threats to the hellbender persist within the Spring River system, conservation efforts may need to occur off-site. Captive breeding and husbandry attempts by the authors along with staff from the Mammoth Spring National Fish Hatchery in Mammoth Spring, Arkansas performed at the hatchery were unsuccessful (1999–2003). Conversely, the Ron Goellner Center for Hellbender Conservation at the St. Louis Zoo has had recent success breeding and rearing hellbenders in captivity (Jeff Ettling and Mark Wanner, pers. comm.). If a successful reintroduction program is established, we suggest that the release of Ozark Hellbenders into the Spring River should only occur following the establishment of habitat refuges and fishing and rafting exclusion zones.

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