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Timely Events in Their Interrelation to Paddlefish and Sturgeon Harvest from 1945-2010

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Abstract: *Due to the high amounts of harvest of natural fish populations, overexploitation can occur and subsequently lead to depleted fisheries. This is especially true for commercially exploited roe-bearing species that exhibit late age at maturation and intermittent spawning. Overexploitation can create an imbalance in natural ecosystem function and in turn jeopardize the livelihood of commercial fishers. Despite the problems created by overexploitation, trends of commercial harvest on large inland river roe-bearing populations have received minimal attention. As such, we evaluated trends in commercial fishing data from 1945-2010 for two roe-bearing species (paddlefish* Polyodon spathula *and shovelnose sturgeon* Scaphirhynchus platorynchus*) from two of the largest inland rivers in North America (Mississippi River and Missouri River) adjacent to Missouri. Commercial sturgeon and paddlefish catch has varied from ∼160 to 35,150 kg over the course of the 55-year duration. Abnormally high catches corresponded to initiation of worldwide caviar markets, onset of extensive regulations on the Missouri and Mississippi rivers, and the Caspian Sea fishery collapse; respectively. Further, our results suggest that the harvest of sturgeon and paddlefish have increased since 1945 and may be influenced by local, regional, and international events. Despite the increase in harvest and the possibility of overharvest, commercial fishing regulations have not been thoroughly evaluated for effectiveness. Further evaluation of current management and regulations of these paddlefish and sturgeon fisheries is suggested, especially considering these fisheries may be influenced by local, regional, and international events. Taking potentially influential events into consideration when evaluating and implementing regulations and authorizing commercial harvest permits are vital in sustaining a long term commercial fishery and protecting the livelihood of commercial fishers.*

Introduction

Fish is an important source of protein for the human population and is the only major food source that is harvested from the wild (Tidwell and Allan 2001). Fish provide ∼16% of animal protein consumed by the human population (FAO 2010). Because of the high demand, large numbers of fish have been harvested, which has led to overexploitation of fish populations in the past (Tidwell and Allan 2001; Pikitch et al. 2005; Ruban and Khodorevskaya 2011). These reductions in fish populations likely occurred due to the removal of reproductive adults (Ruban and Khodorevskaya 2011). The removal of these reproductive adults ultimately reduces the reproductive ability of the populations, and thus will likely be unable to sustain itself (Colombo et al. 2007). Declines in abundance can have an impact on not only the fish community and ecosystem, but also the commercial fishers and the 200 million people that obtain income from fish (Garcia and Newton 1997; Tidwell and Allan 2001).

Because exploitation can have effects on fish populations, commercial fishers are required to report the amount of flesh harvested. These commercial harvest reports allow agencies to assess and evaluate trends in harvest in order to maintain a sustainable commercial fishery. Harvest data provides a guide for agencies to set regulations in order to allow fish to reach a mature size to be able to reproduce and contribute to the populations. These regulations are intended to prevent

overexploitation, and thus protect the livelihood of commercial fishers by ensuring sustainable fish populations. Furthermore, these regulations are especially important for roe-bearing species where mature females are targeted and removed from the population (Quist et al. 2009; Scholten 2009; Ruban and Khodorevskaya 2011). Selective harvest can create an imbalanced population, which can reduce reproductive potential and thus sustainability (Colombo et al. 2007; Ruban and Khodorevskaya 2011). Since populations have declined, the caviar industry has shifted focus from the once-thriving anadromous populations (e.g., Caspian Sea sturgeon; Billard and Lecointre 2001) to those species that reside in large North American rivers. This is especially true for paddlefish *Polyodon spathula* and shovelnose sturgeon *Scaphirhynchus platorynchus*. The increased pressure coupled with late age at maturation and spawning periodicity has put the populations in jeopardy (Jennings and Zigler 2009). Despite the increased harvest pressure and historic declines of shovelnose sturgeon and paddlefish throughout the Mississippi River Basin (Pikitch et al. 2005; Scholten 2009), commercial harvest trends of paddlefish and sturgeon have not been evaluated in recent years. In order to provide guidance on the management of these commercially important species and thus sustainability, we sought to evaluate the trends in harvest of paddlefish and shovelnose sturgeon from 1945-2010. Secondly, we used the trend data and the corresponding temporal specific local, regional, and international events to evaluate their interrelationship.

Methods

Sturgeon and paddlefish commercial harvest data from the Missouri and Mississippi rivers adjacent to Missouri were obtained from the Missouri Department of Conservation (D. Herzog unpub. data). Even though data were derived from both rivers (i.e., Missouri and Mississippi rivers), sturgeon and paddlefish have been shown to move throughout both locations at various life stages (Phelps et al. 2012; Tripp et al. 2014; Phelps et al. 2017). Thus, we pooled harvest from both rivers for all subsequent analyses. These data were obtained from monthly commercial harvest report forms per regulations of the Missouri Department of Conservation from 1945-2010. Furthermore, they were required to report Julian date of harvest and amount of harvest in total weight (kg) for each roe-bearing species. Using the harvest report forms, we calculated total harvest weigh (kg) by year. An extensive search was performed to determine local, regional, and international events that occurred during 1945-2010 and may have influence commercial roe harvest. Using these data (i.e., commercial harvest data and previous events) we qualitatively evaluated their interrelationship. We evaluated each species separately to determine the synergy between harvest and timely historical events. To evaluate synchrony between species in terms of harvest we used Pearson correlation analysis.

Results and Discussion

Commercial sturgeon and paddlefish harvest ranged from ~160 to 35,150 kg over the course of the 55-year duration. Harvest rates were positively correlated ($r=0.76$, $N=55$, $P<0.001$), indicating as paddlefish harvest rates increased sturgeon harvest rates increased as well. Because of the synchrony in harvest between species all subsequent information will we based on the cumulative sturgeon and paddlefish harvest. In terms of commercial harvest, we documented the highest amounts of total harvest during 1980, 1989, and 2001 with multiple events potentially contributing to harvest increases (Figures 1 and 2). Specifically during 1980, we attributed the increase in harvest to a major decline in Caspian Sea sturgeon species (Gesner et al. 2010; Ruban and Khodorevskaya 2011). These declines likely reduced the caviar export from the European Union; thus, increasing the number of commercial fishers and harvest rates on roe-bearing species in North America (Pikitch et al. 2005; Figure 3). Regionally, there also appears to be an increase in price of paddlefish roe (Sample 1981; Scholten 2009).

After 1980, harvest was relatively stable until 1989 when again harvest increased. Specifically, harvest increased from 11,773 kg in 1986 to 39,334 kg in 1989 (Figure 1). This increase in amount of harvest is potentially due to the local and regional closures of commercial paddlefish harvest on the Missouri and St. Francis rivers in 1990, as well as more restrictive regulations proposed during this same time period (e.g., 24 inch minimum length limit on paddlefish statewide). These proposed restrictions may have triggered an increase in harvest due to commercial fishers predicting they may lose the ability to commercially harvest because future closures were likely imminent. Regionally, paddlefish roe prices appear to be at a historic high, which also likely attributed to an increase in harvest (Hoffnagle and Timmons 1989; Scholten 2009). On the international front, the dissolution of the Soviet Union may have also played a role on the increase in harvest (Pikitch et al. 2005; Ruban and Khodorevskaya 2011). When the Soviet Union dissolved, it left the Caspian Sea fishery unregulated. Following the first year of dissolution, illegal harvest reached over 25,000,000 kg, which subsequently led to overexploitation and caused the roe fishery to drastically decline (Ruban

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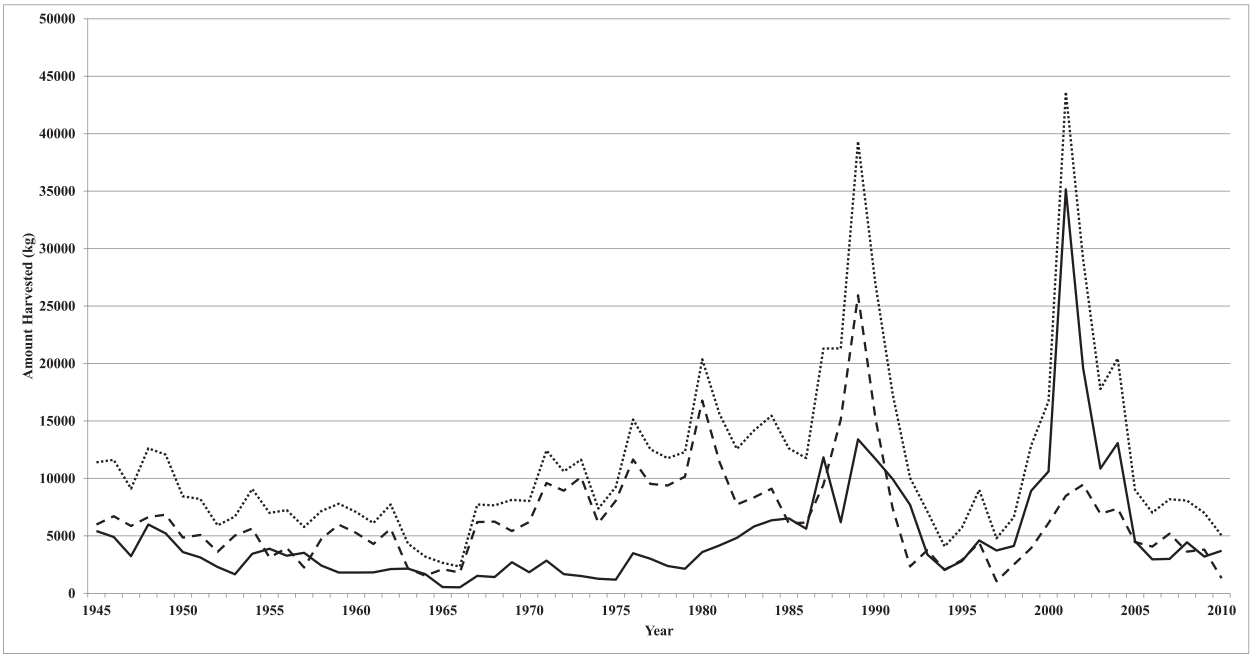
Figure 1. Commercial harvest trends of paddlefish *Polyodon spathula* and shovelnose sturgeon *Scaphirhynchus platorynchus* flesh (kg) in the Missouri and Mississippi rivers adjacent to Missouri from 1945-2010. Dashed line represents harvest of paddlefish, solid line represents harvest of shovelnose sturgeon, and dotted line represents combined harvest of paddlefish and shovelnose sturgeon.



and Khodorevskaya 2011). Khodorevskaya and Krasikov (1999) and Khodorevskaya et al. (2002) estimated all but one species of sturgeon in the Caspian Sea have experienced population declines by as much as 80-90%. This loss of resource, may have caused an increase in harvest pressure on sturgeon and paddlefish in North America in order to supply the caviar demand. Additionally, four species of sturgeon and paddlefish were listed in the Convention on International Trade in Endangered Species (CITES) Appendices by 1989.

Post 1989, harvest rates were relatively consistent but increased to 43,650 kg in 2001 (Figure 1). We attribute this increase in harvest during 2001 to local, regional, and international events. Locally, a regulation was proposed to ban harvest of all sturgeon species throughout the Mississippi River adjacent to Missouri by the Missouri Department of Conservation in 2000. Regionally, a regulation was recommended by MICRA Paddlefish and Sturgeon sub-committee in 1997 to ban harvest of all sturgeon species throughout the Mississippi River basin. Internationally, the Caspian Sea sturgeon populations collapsed and the fishing ban was reinstated in 2000 (Ruban and Khodorevskaya 2011). Additionally in 1998, CITES added all paddlefish and sturgeon spp. to Appendix II and regulated the international trade of all species. These commercial fishing bans and restrictions on roe-bearing species may have caused an increase in harvest pressure of paddlefish and sturgeon due to the loss of these fisheries to supply the roe/caviar demand. These events likely prompted commercial fishers to take advantage and utilize the resource before the possible closure to all sturgeon harvest, and thus their livelihood. Because of their supposition, they likely exerted more effort, and thus harvested more fish to ensure their economic stability. After 2001, harvest stabilized and since has stayed relatively consistent throughout 2010.

Our results suggest that the harvest of sturgeon and paddlefish have increased since 1945 and may be influenced by local, regional, and international events. Despite the increase in harvest and the possibility of overharvest, commercial fishing regulations have not been thoroughly evaluated for effectiveness. Further evaluation of current management and regulations of these paddlefish and sturgeon fisheries is suggested, especially considering these are roe-bearing species that exhibit late age at maturation, spawning periodicity, and are potentially influenced by local, regional, and international events. Taking potentially influential events into consideration when evaluating and implementing regulations and authorizing commercial harvest permits are vital in sustaining a long term commercial fishery and protecting the livelihood of commercial fishers.

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Figure 2. Timely events potentially contributing to increases in paddlefish and sturgeon harvest in the Missouri and Mississippi rivers adjacent to Missouri from 1945-2010.

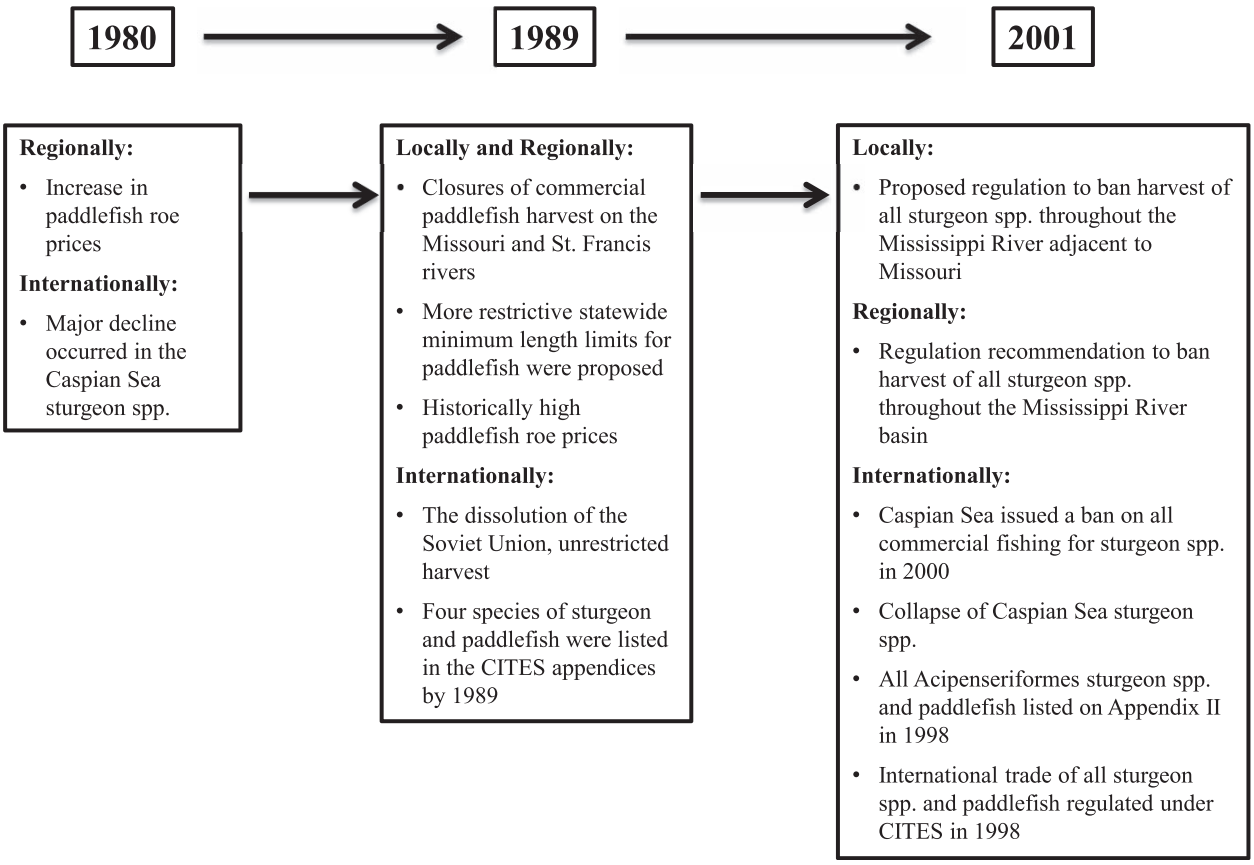

Figure 3. Number of commercial fishers in the Missouri and Mississippi rivers adjacent to Missouri from 1945-2010.

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