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Perceived Influence and Response of River Users to Invasive Bighead and Silver Carp in the Illinois
River

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Abstract

Two United States federally injurious fishes, bighead (*Hypophthalmichthys nobilis*) and silver carp (*H. molitrix*), are established in the Mississippi River Basin and have the potential to colonize the Laurentian Great Lakes. Given this imminent threat, a critical need for stakeholders is an understanding of the potential social influences of this invasion on communities that rely upon the ecosystems bighead and silver carp now inhabit; influences so far unstudied. Using intercept surveys ($n = 469$), we tested for the potential social influences of bighead and silver carp in four river communities; three in which they have established populations (test, Illinois River, Illinois) and one in which they have not (control, Mississippi River, Iowa). Reported principal differences between test and control sites were observed for recreational fishing, aesthetic appreciation of the river, and experience with bighead and silver carp. Our exploratory results indicate that bighead and silver carp may have a negative influence on river usage.

Keywords bighead carp, Illinois River, invasive species, Laurentian Great Lakes, Mississippi River Basin, river users, silver carp

Introduction

Within the past four decades, invasive bighead (*Hypophthalmichthys nobilis*) and silver carp (*H. molitrix*) have colonized much of the Mississippi River Basin (Kolar et al. 2007). Because bighead and silver carp are efficient planktivores, their presence has the potential to negatively influence native fish populations (Irons et al. 2007; Sass et al. 2010) and zooplankton community composition (Sass et al. 2014). Silver carp are also easily startled by boat motors and will jump out of the water when disturbed, posing a significant hazard for recreators, recreational anglers, and commercial fishers. As a consequence of these two behaviors, scientists and resource managers have spent considerable monies

and efforts attempting to control their spread throughout the Mississippi River Basin. The principal geographical focus of these control efforts is the Chicago Sanitary and Ship Canal, which connects the Illinois River Waterway with Lake Michigan (Moy et al. 2011). This canal is of great interest because many stakeholders are concerned that bighead and silver carp may swim through the canal and establish in the Laurentian Great Lakes, which would have the potential to threaten the region's \$7 billion annual sport and commercial fishing industries (ACRCC 2012, Sass et al. 2014).

Given this threat, resource managers, scientists, and stakeholders may benefit from testing whether bighead and silver carp affect ecosystems in which they are established. While the possible stakeholder effect is robust, response of river users to bighead and silver carp has not yet been assessed. Our study aimed to fill this critical void to better understand social implications of the bighead and silver carp invasion.

We present an analysis of intercept surveys ($n = 469$) distributed to the public at gas stations and riverfront areas in four towns located within the Mississippi River Basin. In three of these towns (Beardstown, Havana, and Pekin, Illinois; all located in the LaGrange Reach of the Illinois River), bighead and silver carp are established and have negatively influenced the aquatic ecosystem (Irons et al. 2007; Sass et al. 2010; USGS 2012; Sass et al. 2014). In the fourth town (Bellevue, Iowa; located on Pool 13 of the Mississippi River), bighead and silver carp have not yet established. Our exploratory study tested for the influence of bighead and silver carp on fishing, boating, and aesthetic use of large rivers by comparing reported Illinois River usage within two years (2010 and 2011) and comparing Illinois River usage (2010 and 2011) to Mississippi River usage (2011).

History and Current Management of Bighead and Silver Carp

Bighead and silver carp were intentionally introduced to the United States in the early 1970's to improve aquaculture pond water quality (Kolar et al. 2007; Kelly et al. 2011)¹. Shortly thereafter, they

escaped aquacultural confinement and colonized the Mississippi River. The manner in which they escaped is uncertain; however, flooding in the region is suspected (ACRCC 2012). Bighead and silver carp are efficient filter feeders with diets comprised primarily of phyto- and zooplankton (Jennings 1988; Smith 1989; Vörös 1997; Sampson et al. 2009). Thus, these fishes feed at very low trophic levels and may significantly reduce prey for native fishes (Irons et al. 2007; Sass et al. 2014). They are also highly mobile, very fecund, may spawn several times per year, and quickly grow to large sizes (bighead carp up to 100 lbs., silver carp up to 40 lbs.) (Rasmussen 2002; DeGrandchamp et al. 2008).

During the 1990s, bighead and silver carp were recognized as a rapidly establishing species in the United States (Chick and Pegg 2001; Irons et al. 2011). Today, both species are currently listed in the U.S. as federally injurious and invasive. In 2010, President Obama convened the Asian Carp Regional Coordinating Committee (ACRCC); a collaboration of over 20 federal, state, and local agencies and \$104 million in funding from the Great Lakes Restoration Initiative. The collective purpose of this committee is to prevent bighead and silver carp from establishing in the Great Lakes because the fishes "threaten the ecologic and economic value of the...[region]" (ACRCC 2012, p. 4).

In addition to the ACRCC, public and private initiatives are ongoing in an effort to prevent silver and bighead carp from developing a spawning population in the Laurentian Great Lakes. Initiatives include commercial harvest for human consumption and use as protein media for pharmaceuticals, pet food, or livestock feed. Enterprises also include local community efforts, such as the annual Original Redneck Fishing Tournament. In this tournament, participants compete to catch as many jumping silver carp as possible using only nets or boats (ORFT 2014). Arguably, the most significant action taken thus far to prevent bighead and silver carp from reaching the Laurentian Great Lakes is the construction of three aquatic nuisance species electric dispersal barriers in the Illinois River by the U.S. Army Corp of Engineers, about 30 miles downstream from Chicago in Romeoville, Illinois (ACE 2011; Moy et al. 2011). These barriers have been deemed insufficient by many (e.g. Rasmussen et al. 2011), as some carp may be able to pass through. Those who share this perspective often deem hydrological separation of the

Mississippi River Basin and the Laurentian Great Lakes via the construction of a physical barrier the only permanent solution with the greatest probability to prevent colonization (Rasmussen et al. 2011; Sass et al. 2014).

Whether recreational anglers, commercial fishers, and river users have perceived and responded to bighead and silver carp in established areas is understudied. Such understanding is critically needed, as the principal concern of interested parties regarding the potential establishment of bighead and silver carp in the Laurentian Great Lakes is their unknown social influence on recreational and commercial user groups.

Study Objectives and Hypothesis

Our objective was to test for changes in recreational and commercial river use as a consequence of the bighead and silver carp invasion in the Illinois River, using Bellevue, Iowa (Pool 13, Mississippi River, bighead and silver carp not established) as a control.

We hypothesize that:

- Recreational anglers and commercial fishers in towns along the Illinois River where bighead and silver carp are established will have more interaction (seeing fishes, being struck by them, or being injured) with bighead and silver carp than those in an uninvaded pool of the Mississippi River,
- Bighead and silver carp establishment will decrease recreational anglers', commercial fishers', and those who use the river for aesthetic purposes' river usage.

Description of Study Sites

We selected three river communities (Beardstown, Havana, and Pekin, Illinois) located along the La Grange Reach of the Illinois River as test sites due to high densities of bighead and silver carp (Sass et al. 2010; USGS 2012) (Figure 1). During the 2011 phase of our study, we also selected Bellevue, Iowa to serve as a control. Demographic characteristics of Bellevue were similar to the other three towns. We used this control site to test whether river use frequencies were independent of bighead and silver carp presence.



Figure 1. Map of study sites

Of the four communities surveyed, the median age ranged from about 36 (Beardstown) to 45 (Havana), while median household incomes ranged from about \$31,000 (Havana) to \$46,000 (Pekin) (Table 1). Pekin had the largest population (33,700), followed by Beardstown (6,193), Havana (3,281), and Bellevue (2,246). Of all relevant demographic information, the largest difference between the four

communities was that Beardstown had a significant Latino population (1,102), 22% of the total population. The community with the next largest Latino population was Havana at 0.4% of the total (Table 1).

We should also note that the Mississippi River Basin is not a constant, stable study site. Variables such as flood stage, weather, and economic climate (i.e. flood-stage, fish densities, unemployment levels, and gas prices) vary inter-annually and may affect river use. For example, from March 19 through June 25, 2011, a “large flood crest moved down the Mississippi River from a combination of snow melt and heavy springs rains in the Ohio River Valley” (NOAA 2011), while no analogous events occurred in 2010.

Table 1. Study site demographic information.

	Beardstown, Illinois	Havana, Illinois	Pekin, Illinois	Bellevue, Iowa
<i>Population</i>	6,193	3,281	33,700	2,246
Male	3,202	1,405	16,363	1,053
Female	2,991	1,876	17,337	1,193
<i>Age</i>				
Median age (years)	35.6	44.7	39.7	45.3
Sex ratio (males per 100 females)	107.1	74.9	94.4	88.3
<i>Education</i>				
Percent high school graduate or higher	0.741	0.838	0.88	0.887
Percent bachelor's degree or higher	0.095	0.125	0.153	0.157
<i>Employment</i>				
Population 16 years and over	4,540	2,659	27,220	1,845
Employed	2,729	1,118	15,411	1,170
Unemployed	316	298	1,240	21
Not in labor force	1,495	1,243	10,569	654
<i>Income</i>				
Median household income	35,469	30,723	46,003	44,592
Per capita income	17,528	19,503	24,451	24,576
<i>Place of Birth</i>				
Born in the United States	4,935	3,223	33,249	2,233
Foreign born	1,241	49	336	13
Latin America	1,102	6	154	8

Source. U.S. Census.

Data and Methods

During June – July, 2010 and June – July, 2011, we administered 400 surveys in Beardstown and Havana, Illinois and 560 surveys in Pekin, Illinois to people ≥ 18 years of age using a modified Dillman (2009) approach. In addition, 253 surveys were administered to people ≥ 18 years of age in Bellevue, Iowa in July, 2011. We collected data by distributing mail-back intercept surveys at one gas station and one river front area in each community for a total of eight sampling sites. We distributed 1,213 questionnaires during June, 2010 and July, 2011; 469 usable questionnaires were returned for a response rate of 39%.

Individuals who agreed to participate in our survey had the option of returning the questionnaire on-site or via United States Postal Service First-Class mail. Questionnaires were pre-stamped for return to avoid cost barriers. Our questionnaire consisted of one sheet tri-folded into a brochure, preaddressed, stamped, and included a fastening mechanism (e.g., sticker). The front flap of the questionnaire included a picture of a silver carp, the title of the survey, the research organization, and instructions for return. The first eight questions focused on experiences related to river use and the back of the brochure featured five demographic questions.

Analysis

Using an independent samples *t*-test ($\alpha = 0.10$), we tested for: 1) changes between 2010 and 2011 in usage of the La Grange Reach of the Illinois River; and 2) differences in river use between the La Grange Reach (2010 and 2011) and Pool 13 (2011). A river user was defined as someone who interacted with the river physically (e.g., boating, angling) or by observance (e.g., walking along river, eating lunch on river bank). Frequencies were used to identify respondents as a river user, what activities were participated in, bighead and silver carp experiences encountered, and demographic information.

Data were coded and entered into SPSS 19.0 (SPSS 2010). Due to variability in the consistency of responses, the following data were recoded.

1. The question “Are you an Illinois/Mississippi River user?” was cross-referenced against reported activities of participation. In some cases, for example, a respondent reported not being a river user, but then reported that they fished in either the Illinois or Mississippi rivers. In such cases, the respondent was recorded as a user. The inverse was also true.
2. The percentage of respondents who reported being hit by a bighead or silver carp and the percentage of respondents who reported being injured by a bighead or silver carp were rebased against those who had observed a bighead or silver carp jump.
3. If a respondent reported being hit by a bighead or silver carp, yet they had not reported seeing a bighead or silver carp jump, they were recorded as having observed a bighead or silver carp jump. Correspondingly, if a respondent reported being injured by a bighead or silver carp, yet they had not reported seeing a bighead or silver carp jump, they were recorded as having observed a bighead or silver carp jump and also as having been hit by a bighead or silver carp.

For questions regarding the activities participated in by each respondent, as well as questions regarding physical experiences with bighead and silver carp (i.e., seeing one jump or being injured by one), respondents were only prompted to respond in agreement. For example, if a respondent had not observed a bighead or silver carp jump, then they would simply not answer the question. For this reason, percentages are listed as “Yes” and “Did not respond” (Table 2, 3). The only exception was the question “Are you an Illinois/Mississippi River user”, for if the respondent did not participate in any activities along or in the Illinois or Mississippi rivers, then they were not considered a “user”.

Results

a. Results from the La Grange Reach

In river towns where bighead and silver carp were established, 82.1% of respondents considered themselves to be “river users” and over half reported participating in fishing (52.9%) or boating (53.4%). A majority (65.2%) of respondents from these sites observed a bighead or silver carp jump, and a jumping bighead or silver carp hit 72.2% of these respondents. About 14% of these respondents sustained injuries. About one fifth (21.3%) of those who had observed a bighead or silver carp jump were injured by one.

During 2010-2011, the proportion of respondents who participated in swimming decreased from 28.2%-14.9%, those who participated in boating decreased from 59.5%-47.5%, and those who participated in hunting decreased from 26.2%-17.8%. Decreases in swimming, boating, and hunting were statistically significant at $p < 0.01$, 0.05 and 0.10, respectively. Recreational fishing also decreased over this period, from 55.4% in 2010 to 48.5% in 2011; however, this change was not statistically significant.

River usage increased significantly from about 78.5% in 2010 to 85.6% in 2011 ($p < 0.10$). This change may be explained by a significant increase in aesthetic use of the river (e.g., watching or walking along the river shore), which rose from 9.2% in 2010 to 18.3% in 2011 ($p < 0.01$).

In terms of direct experience with bighead and silver carp, far fewer respondents reported observing a bighead or silver carp jump in 2011 (52.5%) than in 2010 (78.5%). This may be a result of the 2011 flood, as bighead and silver carp are less likely to jump during a flood period due to populations being dispersed throughout a larger area. Regardless, of those who observed a bighead or silver carp jump, there was a significant increase in being hit by a jumping bighead or silver carp between 2010 (56.9%) and 2011 (94.3%) (both $p < 0.001$). In addition, those who reported being injured by a jumping bighead

or silver carp increased significantly from about one in ten in 2010 (9.8%) to about one in five in 2011 (19.8%) ($p < 0.01$).

b. Similarities and Differences between Pool 13 and the La Grange Reach

A large portion of control site respondents in Pool 13 (88.9%) and test site respondents in the La Grange Reach (82.1%) reported being river users. Respondents at both sites reported similar involvement in many recreational activities including boating, swimming, and hunting. Our results demonstrate the general importance of river use in both of these sites. Thus, our findings suggest that respondents across our sites have a strong and reasonably similar relationship to water bodies within the Mississippi River Basin.

Principal differences between the test sites and the control site were observed in levels of reported recreational fishing, aesthetic appreciation of the river, and experience with bighead and silver carp. At test sites, 51.9% of respondents reported participating in recreational fishing, while 66.7% of respondents reported recreational fishing in our control site; a statistically significant difference ($p < 0.05$). A significantly greater percentage of respondents at our control site (26.4%) also reported using the Mississippi River for aesthetic purposes than at the test sites (13.9%) ($p < .05$). Respondents at the test sites reported a greater amount of interaction with bighead and silver carp. A significantly greater proportion reported observing a bighead or silver carp jump (65.2% to 2.8%), being hit by a bighead or silver carp (72.2% to 2.9%), and being injured by a bighead or silver carp (13.9% to 0.0%) (all $p < 0.001$).

Table 2. Differences in river use between 2010 and 2011 in towns in which invasive bighead (*Hypophthalmichthys nobilis*) and silver (*H. molitrix*) carp are present. La Grange Reach, Illinois River communities surveyed included Pekin, Havana, and Beardstown.

	Year survey delivered		Total n=397
	2010 n=195	2011 n=202	
<i>Are you an Illinois River user?</i>			
No	21.5%+	14.4%	17.9%
Yes	78.5%	85.6%+	82.1%
<i>What activities do you participate in while on the Illinois River?</i>			
<i>Recreational fishing</i>			
Did not respond	44.6%	51.5%	48.1%
Participant in recreational fishing	55.4%	48.5%	51.9%
<i>Commercial fishing</i>			
Did not respond	96.4%	96.0%	96.2%
Participant in commercial fishing	3.6%	4.0%	3.8%
<i>Either recreational or commercial fishing</i>			
Did not respond	44.1%	50.0%	47.1%
Participant in recreational or commercial fishing	55.9%	50.0%	52.9%
<i>Boating</i>			
Did not respond	40.5%	52.5%*	46.6%
Participant in boating	59.5%*	47.5%	53.4%
<i>Swimming</i>			
Did not respond	71.8%	85.1%**	78.6%
Participant in swimming	28.2%**	14.9%	21.4%
<i>Hunting</i>			
Did not respond	73.8%	82.2%+	78.1%
Participant in hunting	26.2%+	17.8%	21.9%
<i>Work</i>			
Did not respond	90.8%	96.0%*	93.5%
Participant in work	9.2%*	4.0%	6.5%
<i>Industry</i>			
Did not respond	95.9%	96.0%	96.0%
Participant in industry	4.1%	4.0%	4.0%
<i>Aesthetic purposes/uses (including watching river, walking on rivershore, etc.)</i>			
Did not respond	90.8%**	81.7%**	86.1%
Participant in aesthetic purposes/uses	9.2%	18.3%**	13.9%
<i>Have you seen an Asian carp jump?</i>			
Did not respond	21.5%	47.5%***	34.8%
Yes	78.5%***	52.5%	65.2%
<i>Have you experienced being hit by a jumping Asian carp?</i>			
Did not respond	43.1%***	5.7%	27.8%
Yes	56.9%	94.3%***	72.2%
<i>Have you experienced being injured by a jumping Asian carp?</i>			
Did not respond	90.2%**	80.2%**	86.1%
Yes	9.8%	19.8%**	13.9%

+p < .10, * p < .05, ** p < .01, *** p < .001 or better.

Table 3. Differences in river use between towns in which bighead (*Hypophthalmichthys nobilis*) and silver carp (*H. molitrix*) are present (test group) and not present (control group). Test groups included the communities of Pekin, Havana, and Beardstown, Illinois along the La Grange Reach, Illinois River. The control group included the community of Bellevue, Iowa along Pool 13 of the Mississippi River.

	Test towns 2010 and 2011 n=397	Control town 2011 n=72
<i>Are you an Illinois/Mississippi River user?</i>		
No	17.9%	11.1%
Yes	82.1%	88.9%
<i>What activities do you participate in while on the Illinois/Mississippi River?</i>		
<i>Recreational fishing</i>		
Did not respond	48.1%*	33.3%
Participant in recreational fishing	51.9%	66.7%*
<i>Commercial fishing</i>		
Did not respond	96.2%	97.2%
Participant in commercial fishing	3.8%	2.8%
<i>Either recreational or commercial fishing</i>		
Did not respond	47.1%*	31.9%
Participant in recreational or commercial fishing	52.9%	68.1%*
<i>Boating</i>		
Did not respond	46.6%	56.9%
Participant in boating	53.4%	43.1%
<i>Swimming</i>		
Did not respond	78.6%	81.9%
Participant in swimming	21.4%	18.1%
<i>Hunting</i>		
Did not respond	78.1%	79.2%
Participant in hunting	21.9%	20.8%
<i>Work</i>		
Did not respond	93.5%	87.5%
Participant in work	6.5%	12.5%
<i>Industry</i>		
Did not respond	96.0%	98.6%+
Participant in industry	4.0%+	1.4%
<i>Aesthetic purposes/uses (including watching river, walking on rivershore, etc.)</i>		
Did not respond	86.1%*	73.6%
Participant in aesthetic purposes/uses	13.9%	26.4%*
<i>Have you seen an Asian carp jump?</i>		
Did not respond	34.8%	97.2%***
Yes	65.2%***	2.8%
<i>Have you experienced being hit by a jumping Asian carp?</i>		
Did not respond	27.8%	97.1%***
Yes	72.2%***	2.9%
<i>Have you experienced being injured by a jumping Asian carp?</i>		
Did not respond	86.1%	100.0%***
Yes	13.9%***	0.0%

+p < .10, * p < .05, ** p < .01, *** p < .001 or better.

Discussion and Conclusion

Involvement of local communities in invasive species prevention and management is clearly important, whether it be in mounting control efforts (Buijs et al. 2012), navigating political and/or cultural opinions over control efforts (Norgaard 2007), or assisting scientists in understanding and managing invasions (Sundaram et al. 2012). To our knowledge, we provide the first study assessing the general social influence of bighead and silver carp, invasive species of national concern, on local populations.

Our first hypothesis was confirmed in that recreational anglers and commercial fishers in our test sites along the Illinois River (high densities of bighead and silver carp) would have more interaction with these species than similar user groups in our control site on Pool 13 (low densities of bighead and silver carp). Unsurprisingly, our hypothesis was supported in a robust sense. Our second hypothesis was that this interaction with bighead and silver carp would have a negative influence on river usage. Our results indicated that bighead and silver carp have had a negative influence on river usage as the proportion of respondents who claimed to participate in recreational fishing, swimming, and boating decreased significantly within our test sites between 2010 and 2011. The proportion of respondents who claimed to participate in recreational fishing was significantly lower in our test sites than in our control site.

Nearly three-quarters of respondents in high bighead and silver carp density towns that witnessed these species jump have also been hit by one. In contrast, only 4% of Bellevue, Iowa residents had observed a bighead or silver carp jump. However, of these respondents at our control site, 100% have been hit by a jumping bighead or silver carp (interpret with caution as sample size is < 30). Our finding suggests that when bighead and silver carp populations are robust, a person that observes one of these species is likely to experience it physically. Therefore, we suggest that a principle reason that bighead and silver carp have had a negative impact on river usage in these towns may be a result of perceived risk imposed by jumping silver carp.

Although many survey respondents changed river use as a result of bighead and silver carp density, nearly half of survey respondents reported no change in their river use. We propose three explanations for this observation. The first may be due to the history and culture specific to these river towns. Resident's past and present lives, as well as the history of the town, are intertwined with the river. Thus, the river is part of the community and it may take more than invasive fishes to radically change river use. The second possibility is that as of 2011, no deaths had been confirmed as a result of a bighead or silver carp, and few fish collisions have resulted in watercraft damage. Thus, bighead and silver carp may not be perceived as life threatening. Lastly, most respondents used the river for recreational purposes. Equipment for these activities has already been purchased and money is already invested. Financial investment in recreational equipment, such as boats, may motivate people to continue using the river independent of perceived risks.

Caution must accompany lessons drawn from our results for the following reasons. First, our results only capture changes in river use over a single year (2010-2011). In addition, the Mississippi River Basin flooded in late spring of 2011 and this event may have influenced our results. More rigorous conclusions could be drawn if the study took place over several years, especially if it began before bighead and silver carp became established and continued until well after they had been present for some time. We recommend that future research test whether these changes are specific to these years, some other mitigating factor (e.g., the economic climate between 2010 and 2011), or more suggestive of a current trend in river use changes. Second, the majority of respondents used the river for recreational purposes. Therefore, our findings may not be applicable for those who use the river for commercial purposes. Finally, our results should only be interpreted as potentially indicative of recreators' response to the establishment of bighead and silver carp populations in communities with similar demographic, cultural, and economic circumstances as the sites studied.

Our results provide an initial review of people's individual river use in relation to bighead and silver carp densities in the Mississippi River Basin. As bighead and silver carp populations along the La Grange Reach of the Illinois River continue to increase, researchers should continue to monitor how people

interact with and are influenced by bighead and silver carp. Potential changes that bighead and silver carp may impart on the relationship between the river and people of river towns could have important social, cultural, and economic implications in coming years. Further studies should be conducted to test for the extent of influence these fishes have on other river communities. Overall, our findings provide critical information for resource managers, scientists, and stakeholders involved in developing policy, bighead and silver carp mitigation and management plans, , and others involved in the management of invasive species.

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Notes

¹This practice was quite common at the time, as fish farms in countries around the world, particularly in Europe, imported each species for similar reasons (MDNR 2004).

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