U.S. Fish & Wildlife Service – Great Lakes Region

Fisheries Program

Asian Carp Entrainment, Retainment and Upstream Transport by Commercial Barge Tows on the Illinois Waterway – 2018 Trials

Report prepared by Nathan T. Evans and Mark J. Brouder
Department of Interior
U.S. Fish and Wildlife Service
Carterville Fish and Wildlife Conservation Office
Wilmington Substation Wilmington, Illinois
April 2020

Introduction

Between 2015 and 2017 the U.S. Fish and Wildlife Service, U.S. Geological Survey, and the U.S. Army Corps of Engineers conducted a series of experiments to evaluate the potential risk of upstream transport of Asian carp by commercial barge tows. Results from these interagency studies demonstrated that small fishes can become entrained within the rake-to-box junction gap (hereafter referred to as junction gap) between commercial barge tows operating in the Illinois Waterway and transported upstream. Mark-recapture studies in 2015 and 2016 demonstrated that small [<100 mm total length (TL)] hatchery-reared Golden Shiner *Notemingous crysoleucas* (used as a surrogate for juvenile Asian Carp) can become entrained by moving barges, retained within the junction gap, and transported upstream distances of at least 15.5 km. Additionally, these studies demonstrated that juvenile Golden Shiners retained in junction gaps could be transported through navigation locks, as well as across the Electric Dispersal Barrier System (EDBS) within the Chicago Sanitary and Ship Canal. In 2017, the U.S. Fish and Wildlife Service directly assessed the vulnerability of Asian carp being retained within the junction gap of barges and transported upstream via mark-recapture studies using juvenile Silver Carp *Hypophthalmichthys molitrix*. Results of the 2017 trials demonstrated that Silver Carp with a mean TL of 41.6 mm can be retained within the junction gap of barges and transported up to 6.4 km upstream in the Illinois River. However, during the 2017 study, fish were released directly into the barge's junction gap and, therefore, only the vulnerability of Silver Carp to be retained and not entrained was quantified. In 2018, we conducted an experimental study to assess the potential for juvenile Asian carp to be both entrained and retained within barge junction gaps and transported upstream and into a navigation lock chamber in the Illinois Waterway.

Methods

Wild juvenile Silver Carp, Bighead Carp *Hypophthalmichthys nobilis*, and Grass Carp *Ctenopharyngodon idella* were captured using dip nets from the La Grange Pool of the Illinois River in late-June and early-July 2018. Captured fishes were held in captivity at the Illinois Natural History Survey - Great Rivers Field Station located in Alton, IL until October 2018. While in captivity fish were maintained in flow-through Mississippi River water, grew from an average TL of 20 mm to 93 mm, and appeared healthy at the time of the experimental trials.

A commercial tow consisting of six hopper barges (~60 m x 11 m each) configured two barges wide by three barges long was used during the study; a common configuration employed by commercial carriers on the Illinois Waterway (Figure 1). The tow was operated using standard course tracks at speeds between 3.70 - 4.26 km/h as it made an upstream transit of 4.21 km in the La Grange Pool in the vicinity of Peoria Lock and Dam (Figure 2). In total, ten experimental trials consisting of five marked fish trials and five wild fish trials were conducted between October 17, 2018 and October 25, 2018.

All marked-fish trials began approximately 4.21 km downstream of the Peoria Lock and ended when the barge entered the lock chamber and the lock doors closed behind the barge. At the start of each of the marked-fish trials, a known number of marked (fin-clipped) Asian carp were released either in front of the moving barge (n=2), directly within the barge junction gap (n=1), or both (n=2; Table 1). Unique fin clips were used for each of the experimental trials. All fish were released on the port side of the barge tow. Releasing marked juvenile Asian carp in

front of the barge tow ensured that the barge would pass over the juvenile fishes, and allowed us to assess the potential for a moving barge to entrain and subsequently retain juvenile Asian carp in the barge's junction gap. Releasing marked juvenile Asian carp directly into the junction gap allowed us to assess the potential for a moving barge to retain juvenile Asian carp in the junction gap and transport them upstream. The total length (mm) of a subsample (n = 21-51 individuals per trial) of the marked fishes was measured and recorded prior to release. In total, 1,256 Asian carp were released during the five marked-fish trials.

Wild-fish trials began either 4.21 km downstream of Peoria Lock (n=3) or just above Peoria Lock (n=2) then extended 4.21 km upstream. All experimental trials were conducted in an upstream transit direction. At the start of a wild-fish trial no fish were released, instead wild-fish runs allowed us to assess the potential for a moving barge to entrain wild fish in the barge's junction gap. During each of the ten experimental trials, freely swimming fishes within the barge's junction gap were monitored via an ARIS high-definition imaging sonar (Sound Metrics, Bellevue, WA). The ARIS files were viewed in real time during the transit, as well as recorded for later analysis.

At the conclusion of each experimental trial, a cast net was used to sample the junction gap in an attempt to recapture marked or wild fish. If fish were shown to be present via the real-time ARIS sonar, net casts were "aimed" in an attempt to capture those fish. Aiming the net was carried out by marking the distance of fish observed from the transducer face and then casting the net over the distance indicated on the real-time sonar screen. After attempting to capture the fish observed on the ARIS, or if no fish were present on the sonar screen, a minimum of three net casts were conducted to sample, as best as possible, the entirety of the junction gap. After the conclusion of the field trials, the recorded ARIS sonar files were analyzed to determine if any of the recorded fishes, including both released marked fish and wild fish, appeared to be retained within the junction gap and if so, for how long. Surface water temperatures (ºC) were recorded at the beginning of each experimental trial.

Results

Of the 1,256 Asian carp (mean = 93 mm TL; range = 56 – 179 mm TL) released during the five marked-fish trials, two fish were recaptured during one of the five experimental trials where 150 fish had been released in front of the barge and 150 fish had been released directly into the barge's junction gap. No marked fish were recaptured during any of the other four marked-fish trials (Table 1).

Of the two Asian carp that were recaptured both were Silver Carp. One (85 mm TL) of the two recaptured individuals had been released in front of the barge and the other individual (92 mm TL) had been released directly into the barge's junction gap. Both individuals were recaptured on the starboard side of the tow despite being released on the port side (Figure 2). No fish were recaptured in the barge's junction gap at the end of any of the five wild-fish trials.

In total, across the ten experimental trials, 75 individual fish were observed in the barge's junction gap via the ARIS sonar. Of the 75 individuals observed only three were present on the sonar for greater than 30 seconds (Figure 3). Of the 75 individual fish recorded on the ARIS, 31

of the individuals were recorded during the cumulative five wild-fish trials. Nineteen individual fish were recorded during the cumulative two marked fish trials where fishes were stocked in front of the barge. Similarly, 17 individual fish were recorded during the cumulative two marked fish trials where fishes were released both in front of the barge and directly into the junction gap. Eight individual fish were recorded during the marked-fish trial where fish were only stocked directly into the junction gap.

Mean surface water temperature for the duration of the experiment was 11.4 ºC and ranged from 10.7 ºC to 13.2 ºC. The mean surface water temperature for the marked-fish trials was 11.5 ºC and ranged from 10.7º C to 13.2º C. The mean surface water temperature for the wild-fish trials was 11.4 ºC and ranged from 10.8 ºC to 11.8 ºC.

Discussion

Two juvenile Silver Carp were recaptured in the barge's junction gap during this study. Both individuals were marked fish that were recaptured during the same experimental trial from which they were released. One of the two individuals was released in front of the moving barge and subsequently entrained from the water column and retained in the junction gap until the barge tow stopped in the lock chamber 4.2 km upstream. The other individual was released directly into the junction gap and was retained until the barge tow stopped in the lock chamber, again, 4.2 km upstream. These results indicate that there is potential for commercial barge tows to entrain and retain juvenile (< 92 mm TL) Silver Carp in junction gaps, and transport them upstream and into lock chambers. The low recapture rate of the 1,256 marked Asian carp that were released during this study suggests that Asian Carp between 56 and 179 mm TL (the size range of fish used in this study) may have the ability to avoid or escape entrainment and retention in a barge's junction gap. These results differ from results of our U.S. Fish and Wildlife Service 2017 study, where 23 of 1,200 juvenile (<65 mm TL) Silver Carp released directly into the junction gap were recaptured after being retained and transported upstream between 0.8 and 6.4 km.

The dissimilarity between our findings in this study compared to those of our 2017 study is likely due to differences in the experimental methods used during our 2017 and 2018 studies. The potential exists that evaluating both entrainment and retainment in 2018 by releasing fish in front of the barge (entrainment), as well as directly into the junction gap (retainment), as opposed to only evaluating retainment in 2017 by releasing fish directly into the junction gap resulted in the observed lower recapture rate in 2018 relative to our 2017 study results. Fish released in front of the barge in 2018 to evaluate entrainment had to remain in the path of and travel under the barge tow for approximately 60 m (the length of the barge) before potentially becoming entrained and subsequently retained in the junction gap.

Similarly, sampling the junction gap for marked fish at the end of the tow transit in 2018, after the barge had entered the lock chamber and the lock doors closed behind it, as compared to periodically throughout the tow transit in 2017, may have also contributed to the lower recapture rate observed in 2018. As a barge slows while entering and ultimately stopping in the

lock chamber, the retainment potential of fish trapped in the junction gap decreases, as the hydrologic forces that can retain fishes in the junction gap no longer exist.

Last, but certainly not least, the mean size of fish used in the current study was 93 mm TL, more than double that of fish used in 2017 (mean = 42 mm TL). Fish used in this study were approximately twice as large as those used in 2017, which likely resulted in an increased potential for fish to avoid entrainment, and/or minimize retainment by escaping from the barge's junction gap as a result of the increased swimming ability of larger fish. The potential for the larger-sized fish used in this study to be able to avoid entrainment and/or escape retainment is supported by the ARIS sonar data collected concurrently. The duration of time spent by the majority of fish observed swimming within the junction gap was ≤ 10 seconds.

The effects of Asian carp size and swimming ability were not assessed in this study. A size threshold at which Asian carp swimming ability becomes greater than that of the entrainment and retainment forces that are present within a barge's junction gap likely exists. Although this size threshold remains unknown, the results of this study, along with those from our 2017 study, provide some, albeit it limited evidence that such a size threshold may exist somewhere between 42 mm and 93 mm based on the mean total lengths of the fish released in 2017 and 2018. Additional research involving fish swim tunnel performance measurements, modeling of the hydrologic forces present within barge junction gaps, and field experiments involving replicated, size-stratified, fish releases would be necessary in order to gain a mechanistic understanding of how Asian carp size and swimming ability influence their entrainment and retainment potential by commercial barge tows operating in the Illinois Waterway.

Conclusion

The results of this study demonstrate that marked juvenile Asian carp (< 92 mm TL) can become entrained in a barge's junction gap, retained, and transported upstream by commercial barge tows into a lock chamber. However, no wild Asian carp were captured in the junction gap during this study and there is no evidence that wild Asian carp were entrained, retained, or transported upstream by commercial barge tows. However, the possibility exists that at the time of year this study was conducted (i.e., mid-October, 2018), wild juvenile Asian carp in the Illinois River were of a size too large to be vulnerable to barge entrainment/retainment. Conducting similar studies earlier in the year when wild Asian carp are present at a smaller size than those used in this study would be necessary to accurately assess the potential entrainment of small wild Asian carp within the Illinois Waterway.

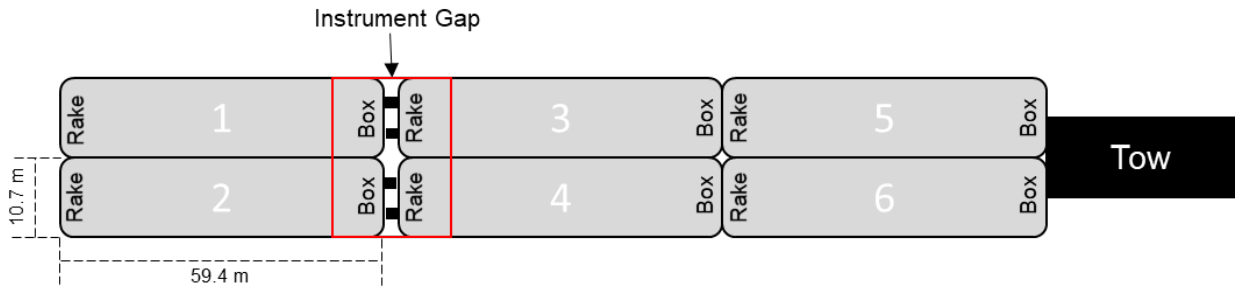

Figure 1. Tow configuration used during 2018 Asian carp entrainment, retention, and transport trials. Juvenile Asian carp were stocked either in front of the center of barge #2 or directly into the rake-box junction gap identified by the red rectangle.

Figure 2. Map showing the start and terminus of the 4.21 km transit used for the five Asian carp marked fish trials. All juvenile Asian carp were stocked at the start location and the barge's junction gap was sampled after the barge stopped inside Peoria Lock.

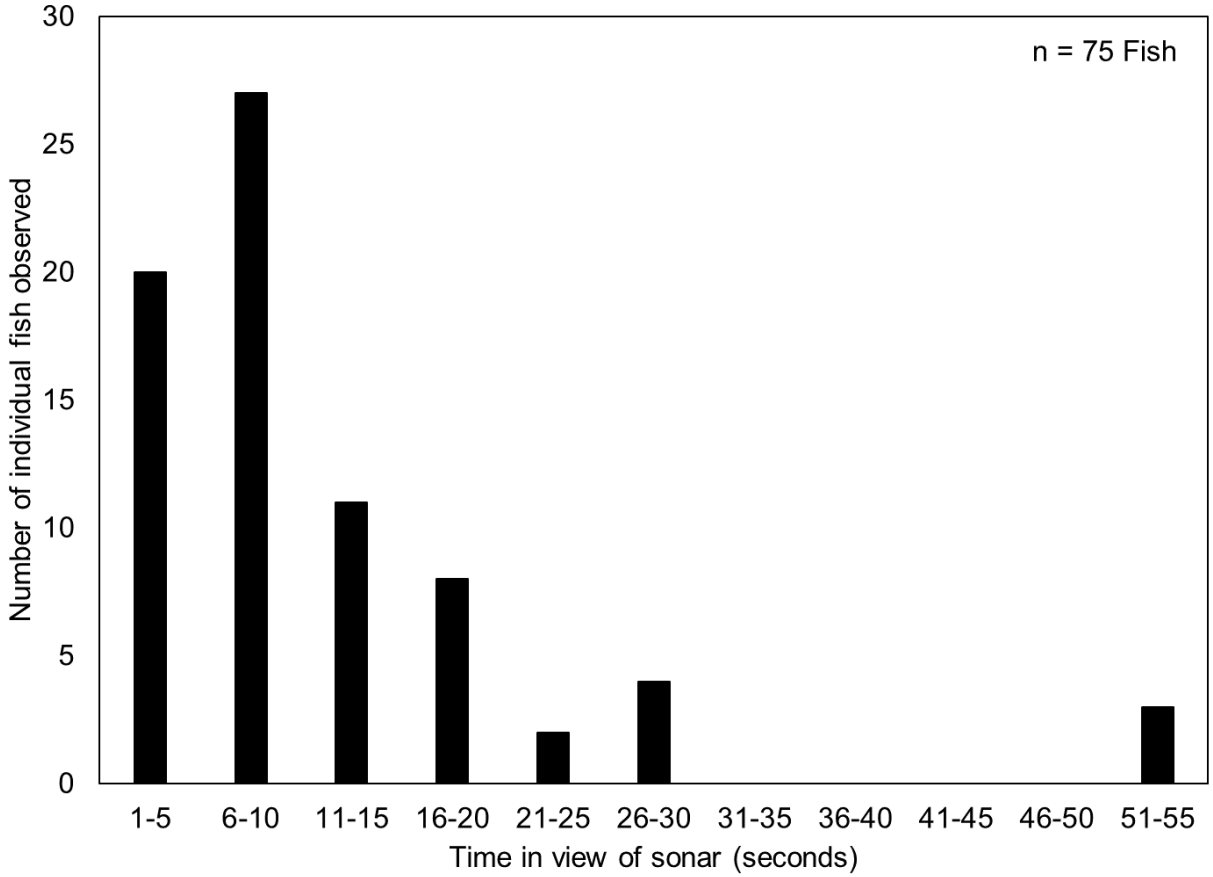

Figure 3. Histogram illustrating the length of time, in seconds, that individual fish were observed within the barge's box-rake junction gap via the ARIS high-definition imaging sonar.

Table 1. Number, mean total length, and total length range of fishes released and recaptured during each of the five marked fish runs.

Run	# Released Front	# Released Junction Gap	# Recaptured	Mean TL (mm)	TL Range (mm)
#1	98	0	0	108	74 - 156
#2	386	0	0	103	60 - 179
#3	150	150	2	82	56 - 109
#4	150	150	0	87	58 - 140
#5	0	172	0	96	64 - 125
Total	*784*	*472*	*2*	*93*	*56 - 179*