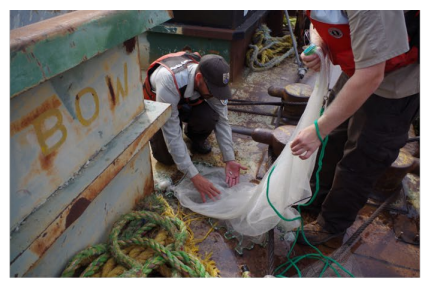
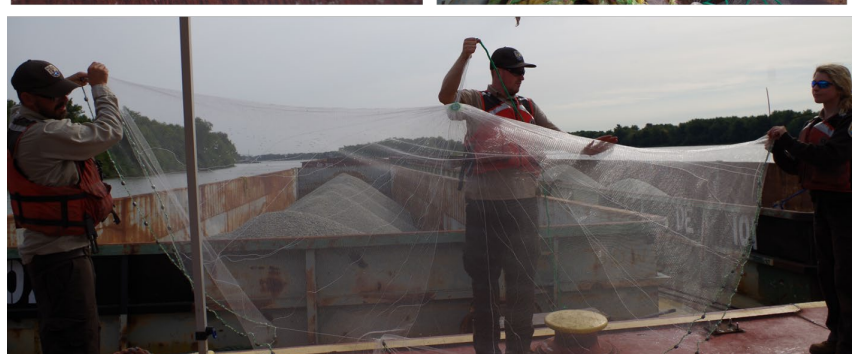
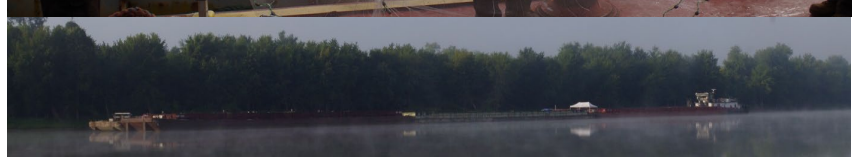
U.S. Fish & Wildlife Service - Midwest Region

# Fisheries Program

# Dynamics of Silver Carp Entrainment and Transport by Commercial Tows on the Illinois Waterway - Preliminary Results 2017 Field Studies





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**December 2017**

## Disclaimer

The results presented herein are preliminary in nature and subject to change. Internal and external peer review processes are underway. The final results of this research will be made available through a final internal document and through peer reviewed literature upon completion of the peer review process.

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## Introduction

Results from interagency studies conducted during 2015 and 2016 suggested that small fish can become entrained within junction gaps between barges in commercial tows, transported upstream over long distances (at least 9.6 miles), through lock chambers, and across the Electric Dispersal Barrier System (EDBS) in the Chicago Sanitary and Ship Canal (Davis et al. 2016). Those studies, utilized hatchery reared Golden Shiners (*Notemigonus crysoleucas*) as surrogates to understand potential vulnerabilities of the EDBS in preventing transfer of Asian carp into the Great Lakes basin. However, findings from laboratory studies suggest that Golden Shiners possess swimming capabilities that differ from Asian carp species (Boyd and Parsons 1998, Newbold et al. 2016). During 2017, the U.S. Fish and Wildlife Service (USFWS) conducted a series of experimental trials designed to directly examine the vulnerability of Silver Carp (*Hypophthalmichthys molitrix*) to potential upstream transport by tow entrainment.

## Methods

Wild juvenile Silver Carp were captured from the La Grange pool of the Illinois River using passive mini-fyke nets. They were held in captivity at the Illinois Natural History Survey- Great Rivers Field Station in Alton IL and maintained using recirculated river water for approximately one month until the study took place. The captive Silver carp grew substantially (from an average of 20mm to an average of 42mm) during their time in captivity and appeared healthy at the time of the field trials. A commercial tow consisting of six hopper barges (200' x 35' each) configured two barges wide by three barges long was utilized during the study, this is a common configuration utilized by commercial carriers on the Illinois Waterway (Figure 1). The tow was operated using standard course tracks at speeds between 2.5-4.0 mph as it made upstream transits of various distances within the Alton and La Grange pools of the Illinois River (Table 1). Juvenile age -0 Silver Carp (mean size = 41.6 mm TL; S.D. 6.0 mm) were marked with various fin clips and stocked (n=50-300 fish/trial) into the rake- box junction gap between barges in the moving tow. During upstream transits, schools of freely swimming Silver Carp were monitored with an ARIS™ multi-beam sonar system in the junction spaces between barges. At several locations during each upstream transit, attempts were made to recapture fish from the schools observed via sonar with a small mesh cast net. The recapture attempts were conducted to confirm the identity of fish within the junction gap. A total of 9 juvenile Silver Carp transport trials were conducted. These trials ranged in upstream transit length from 2.2 - 9.5miles.

Additionally, several trials were conducted to examine the entrainment dynamics associated with larger age 0 and age 1 Silver Carp (131-325 mm). During this portion of the study, Silver Carp were captured from the wild near the trial locations, held in tanks onboard the tow for one day, and implanted with Vemco V5 acoustic transmitter tags. After recovery from surgery, these fish were stocked into the rake-box junction gap of the moving tow during upstream transits. An acoustic receiver placed within the junction gap monitored the length of time that these Silver Carp remained within the junction gap.

## Results

During all juvenile entrainment trials, sonar observations confirmed that schools of small fish remained within the rake-box junction gap for substantial periods of time (up to 3.5 hours) and experienced upstream transport of at least 2.0 mi. (range= 2.0-9.5 mi.; mean= 3.9 mi., S.D.= 2.2 mi.). Confirmation that the small fish targets that were observed via sonar were in fact Silver Carp stocked during the trial, was accomplished through physical recapture events. Although sonar data suggested

that schools of small fish remained within the rake-box junction gap for at least 2.0miles during all trials, marked Silver Carp were physically recaptured during only 77.8% of trials. The maximum upstream transport distance for a Silver Carp that was confirmed via physical capture during this study was 4.0 miles (Table 1). Larger Silver Carp (mean TL = 242.6, S.D. = 59.2, n=7) tagged with acoustic transmitters all left the rake-box junction gap of the upstream transiting tow within 4 minutes (Table 2).

## Discussion

Based on these preliminary study results, small Silver Carp (< 60 mm) can be transported upstream while entrained in commercial tow junction gaps over long distances. These results are consistent with previous observations made on entrainment dynamics of Golden Shiners (Davis et al. 2016). When small fish, including Asian carp spp. encounter a commercial tow moving upstream, those fish can become entrained in the boundary layer of water near the tow's hull and within junction gap spaces where recirculating water currents retain them as the tow travels upstream. Larger Silver Carp (> 130 mm) appear to have swimming capabilities which allow them to avoid entrainment within junction gaps between barges in a tow. The size threshold at which the swimming ability of Silver Carp becomes strong enough to avoid or escape entrainment within barge junction gaps is currently not fully understood. Information gained from these studies can be leveraged to inform our understanding of the potential entrainment and transport of small Asian carp in other waters of the United States actively used for commercial barge transit and occupied by established populations of Asian carp.

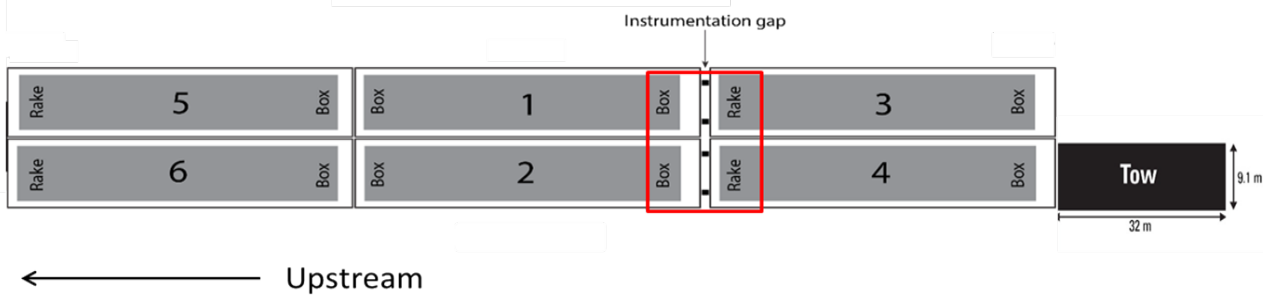


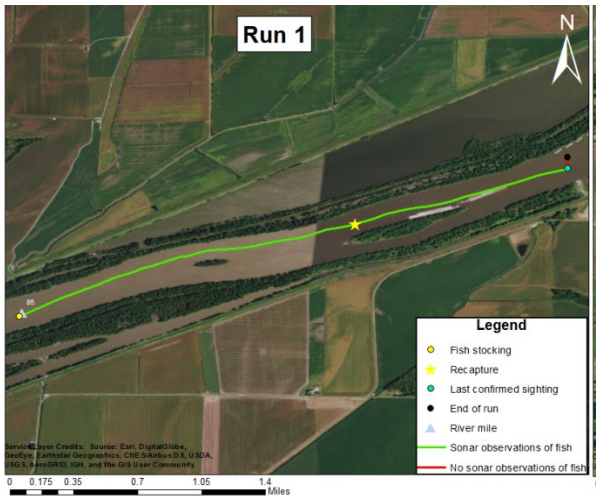

**Figure 1.** Tow configuration used during 2017 Asian Carp entrainment and transport trials. All juvenile Silver Carp were stocked into the rake-box junction gap identified by the red rectangle.

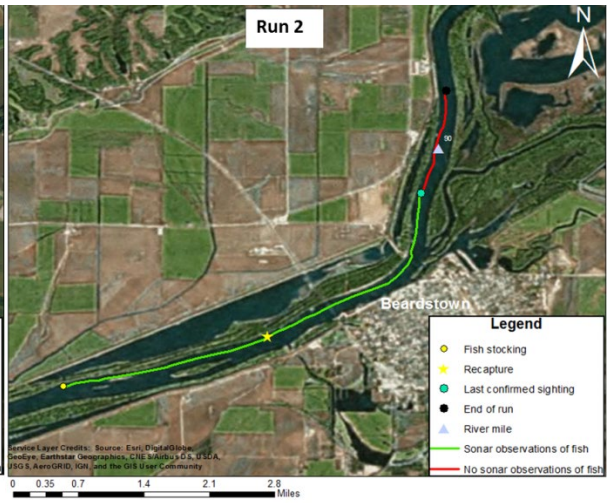
**Table 1.** Results from juvenile Silver Carp transport trials. Mean Silver Carp length for individuals stocked during these trials was 41.6 mm TL; S.D. 6.0 mm.

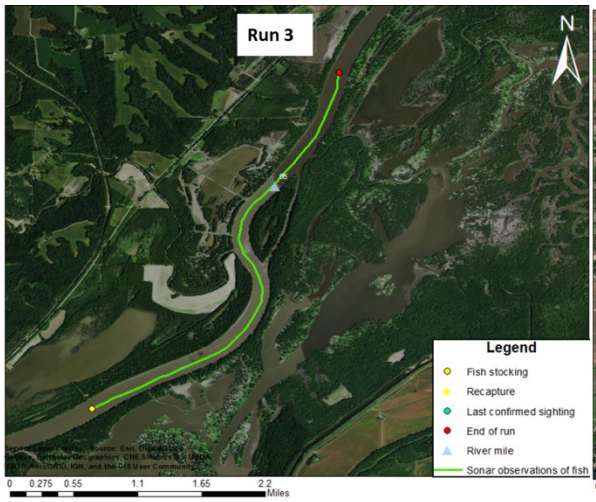
| Trial ID | Date | Start Time | Start River Mile (RM) | End River Mile (RM) | Transit Length (RM) | Number Silver Carp Stocked | Last Sonar Observation Time | Last Sonar Observation (RM) | Miles Transported (Sonar) | Recaptures | Last Recap Time | Recapture Max Miles Transported |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 12-Sep-17 | 9:35:50 | 84.6 | 87.5 | 2.9 | 50 | 10:33:25 | 87.2 | 2.6 | 3.0 | 10:07:25 | 2.2 |
| 2 | 13-Sep-17 | 9:35:30 | 85.5 | 90.6 | 5.1 | 300 | 11:13:30 | 89.5 | 4.0 | 2.0 | 10:20:15 | 1.9 |
| 3 | 13-Sep-17 | 13:08:49 | 92.4 | 96.2 | 3.8 | 300 | 14:41:47 | 96.0 | 3.6 | 0.0 | N/A | 0.0 |
| 4 | 14-Sep-17 | 9:45:16 | 85.5 | 95 | 9.5 | 200 | 13:33:18 | 95.0 | 9.5 | 5.0 | 10:32:59 | 1.8 |
| 5 | 19-Sep-17 | 10:37 | 64 | 69 | 5 | 100 | 12:04:36 | 67.5 | 3.5 | 0.0 | N/A | 0.0 |
| 6 | 19-Sep-17 | 12:59:55 | 69.7 | 71.9 | 2.2 | 100 | 13:49:51 | 71.1 | 2.0 | 9.0 | 13:53:07 | 2.2 |
| 7 | 20-Sep-17 | 9:13:40 | 57.8 | 60.5 | 2.7 | 50 | 9:35:28 | 60.5 | 2.7 | 1.0 | 10:51:12 | 3.5 |
| 8 | 20-Sep-17 | 10:26:53 | 61 | 65.5 | 4.5 | 50 | 12:11:56 | 65.5 | 4.5 | 2.0 | 10:51:12 | 0.5 |
| 9 | 20-Sep-17 | 12:14:31 | 65.5 | 70 | 4.5 | 50 | 12:15:22 | 68.3 | 2.8 | 1.0 | 13:57:00 | 4.0 |

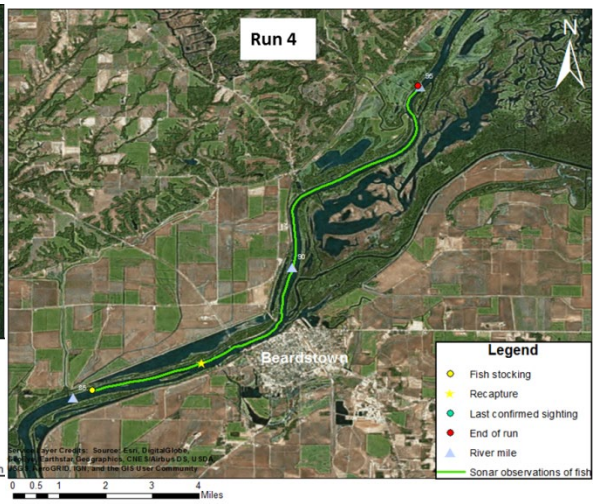
**Table 2.** Acoustic tag detections for Silver Carp stocked in rake-box junction gap of tow.

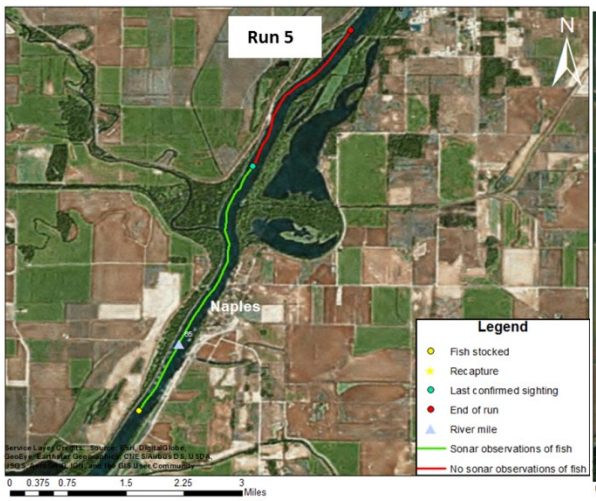
| Tag ID | Date | Silver Carp Length (mm) | Stock Time | Last Detection Time | Detections | Time in Junctions Gap (Min.) |
|---|---|---|---|---|---|---|
| 7391 | 9/14/2017 | 325 | 11:09 | N/A | 0 | 0 |
| 7371 | 9/14/2017 | 220 | 12:00 | 12:02 | 1 | 2 |
| 6951 | 9/14/2017 | 236 | 12:38 | 12:39 | 1 | 1 |
| 6939 | 9/14/2017 | 255 | 12:46 | N/A | 0 | 0 |
| 6925 | 9/14/2017 | 265 | 12:54 | N/A | 0 | 0 |
| 7649 | 9/14/2017 | 266 | 13:08 | 13:09 | 1 | 1 |
| 7559 | 9/21/2017 | 131 | 10:39 | 10:43 | 3 | 4 |

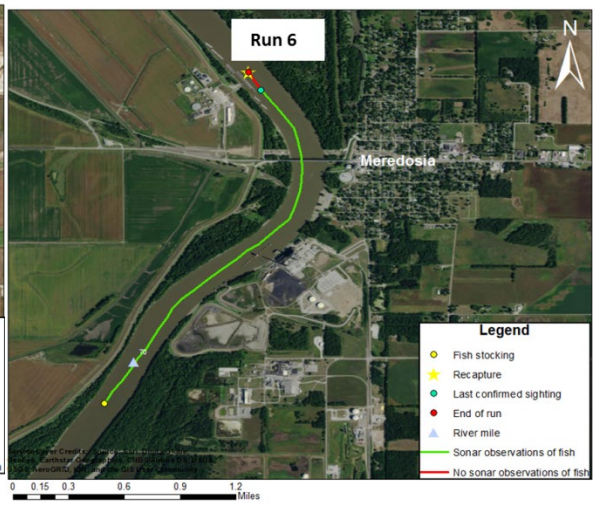

Run 1
N
Legend
Fish stocking
Recapture
Last confirmed sighting
End of run
River mile
Sonar observations of fish
No sonar observations of fish
0 0.175 0.35 0.7 1.05 1.4
Miles


Run 2
N
Beardstown
Legend
Fish stocking
Recapture
Last confirmed sighting
End of run
River mile
Sonar observations of fish
No sonar observations of fish
0 0.35 0.7 1.4 2.1 2.8
Miles


Run 3
N
Legend
Fish stocking
Recapture
Last confirmed sighting
End of run
River mile
Sonar observations of fish
0 0.275 0.55 1.1 1.65 2.2
Miles


Run 4
N
Beardstown
Legend
Fish stocking
Recapture
Last confirmed sighting
End of run
River mile
Sonar observations of fish
0 0.5 1 2 3 4
Miles


Run 5
N
Naples
Legend
Fish stocked
Recapture
Last confirmed sighting
End of run
River mile
Sonar observations of fish
No sonar observations of fish
0 0.375 0.75 1.5 2.25 3
Miles


Run 6
N
Meredosia
Legend
Fish stocking
Recapture
Last confirmed sighting
End of run
River mile
Sonar observations of fish
No sonar observations of fish
0 0.15 0.3 0.6 0.9 1.2
Miles

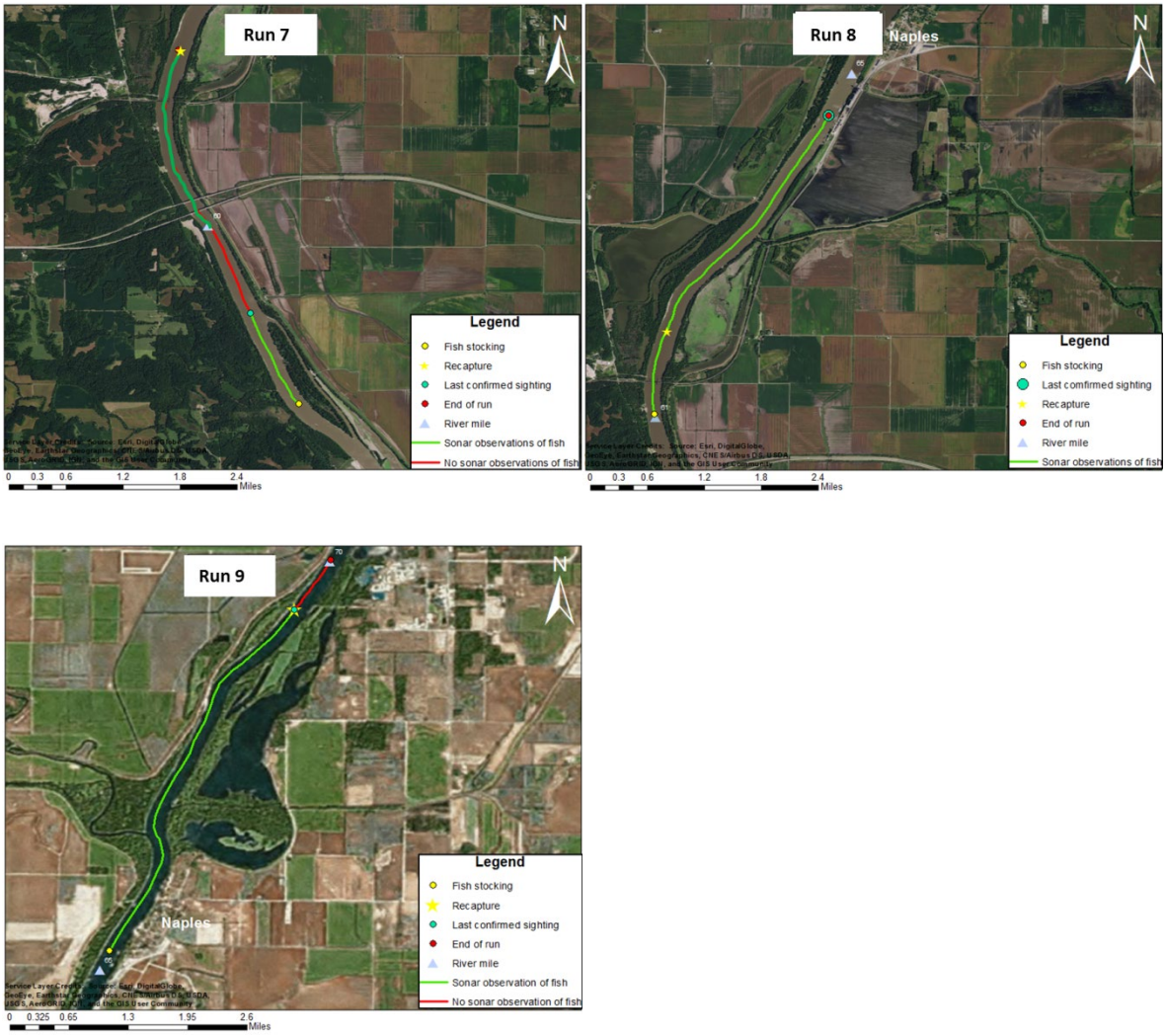



**Figure 2.** Maps of juvenile Silver Carp tow entrainment and transport trials. Yellow star indicates location of furthest upstream Silver Carp recaptures during a trial. Green track line indicates where fish were observed within the junction gap via sonar. Red track line indicates point when no fish were observed via sonar. All trials proceeded in the upstream direction (N). There were no physical recaptures during runs 3 and 5.

## References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Newbold, L. R., Shi, X., Hou, Y., Han, D., & Kemp, P. S. (2016). Swimming performance and behaviour of bighead carp (Hypophthalmichthys nobilis): Application to fish passage and exclusion criteria. *Ecological Engineering*, *95*, 690-698.