



### Introduction

Acoustic telemetry refers to the use of sound (acoustics) to relay information from a distance (telemetry). Researchers use this technique to remotely track the movements of individual fish. In the Winnebago System, lake sturgeon movements are tracked to collect information about habitat use, spawning migrations and mortality that inform lake sturgeon management.

Over 200 lake sturgeon have been implanted with acoustic tags over the last two decades, each with a battery life of up to 10 years. Over the same span, more than 60 acoustic receivers (Image 1) were installed near spawning sites, river mouths and lakes to detect tagged fish as they swim by (Images 2 and 3). In December 2021, receivers were placed in Lake Winnebago's southern half and the northern half was completed by June 2022. This made it possible to assess mortality and habitat use by lake sturgeon within the lake. Establishment of the receiver array, combined with persistent tagging projects, have enabled managers to study the movement histories of individual lake sturgeon throughout the system, all year round.

An acoustic telemetry program of this magnitude generates an overwhelming amount of data that can be challenging to summarize. This is due to the unique movement patterns exhibited by individual fish and the year-to-year variability in climate conditions that influence their behavior. The inaugural Winnebago Lake Sturgeon Acoustic Telemetry Report will acknowledge these variables while summarizing the movements of 20 tagged lake sturgeon during the 2023 spawning migration.



Image 1: Acoustic receiver ready for deployment. Credit DNR

### Objectives

1. Estimate how many tagged lake sturgeon spawned in 2023.
2. Determine spawning windows, spawning locations and trends in lake sturgeon movement during the 2023 spawning migration.
3. Discuss lake sturgeon occupancy in three zones of Lake Winnebago from June 2022-June 2023.



Image 2: Map of acoustic receivers in the Winnebago System. Receivers near spawning sites are in red. Credit DNR.

### DNR Contact

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### Methods

**Sampling:** Lake sturgeon were captured by electrofishing at various locations in the Upper Fox River, Wolf River and neighboring tributaries between 2013 and 2018 in the fall and spring months.

**Tagging:** V16 (10-year battery) acoustic tags were implanted into captured lake sturgeon. Lake sturgeon were also measured, sexed and given a Passive Integrated Transponder (PIT tag) if necessary and then released back into their river of origin.

**Data Download:** Acoustic receivers were visited annually between May and July. Movement data was downloaded onto a laptop, and receivers were serviced with new batteries.

**Data Management and Analyses:** Movement data from receiver downloads were added to each Sturgeon's "fish movement profile." After enough consecutive movement history is collected, seasonal/yearly movements are mapped and various analyses may be performed.

### Acoustic Telemetry Terms

**Tags** "talk" to acoustic receivers. They produce pings in sequences that are uniquely identifiable and each has a unique number. When put into a fish, the tag connects to any acoustic receivers that the fish swims by depending on environmental conditions and proximity to the receiver.

**Receivers** are placed in the water year-round to "listen" for nearby acoustic tags. They identify and store data from nearby tags by converting their sound signals into numerical data or "detections."

**Detections** are the data generated when an acoustic tag connects with an acoustic receiver. Each detection includes a tag number, date, and time that a fish was detected. They are most basic form of acoustic telemetry data.

**Days Spent** is a metric used to consolidate detection data. A tagged fish may generate dozens of detections per day when close to an acoustic receiver. Researchers can group these detections into days to determine how long a fish spent at a specific location. In this report, one or more detections per calendar date is equivalent to one day spent.

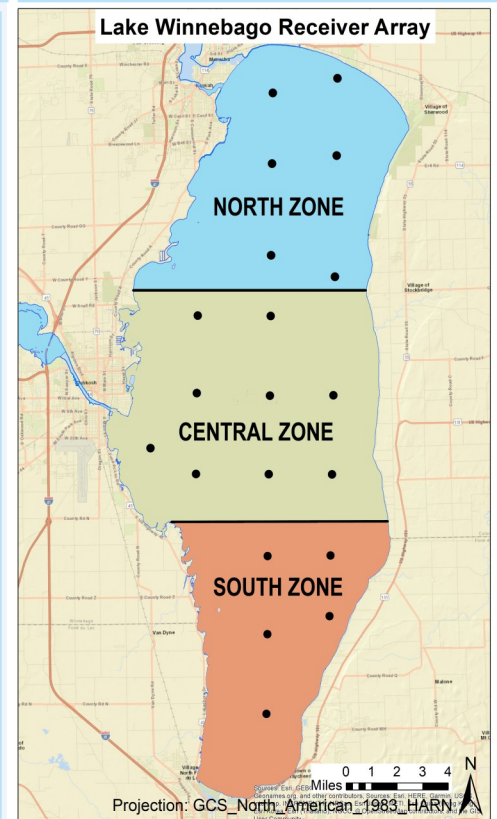


Image 3: Map of Lake Winnebago Receiver Array. Credit DNR.

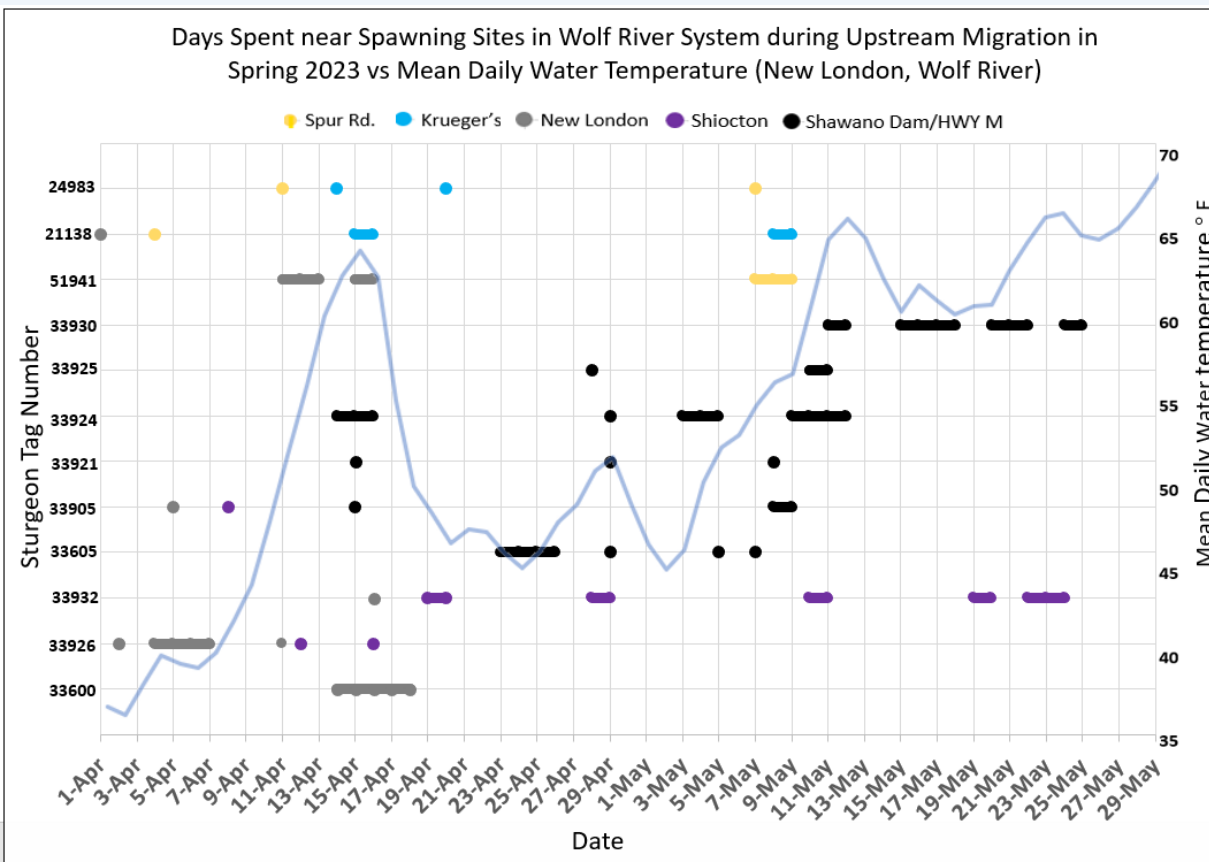


2023 Lake Sturgeon Acoustic Telemetry Report  
Winnebago System

Wolf River System Movement Summary

Detections on receivers near spawning sites were used to identify tagged lake sturgeon we believe spawned in 2023. They were also used to estimate spawning windows and locations. However, detections do not always reflect spawning behavior. As lake sturgeon migrated upstream, they passed multiple spawning sites. This resulted in detections that indicated upstream movement, but not necessarily spawning. Also, some sturgeon were detected when water temperatures were not suitable for spawning which can make estimation of spawning windows challenging. For these reasons, environmental and behavioral parameters were used to isolate spawning-related detections from others. **Tagged lake sturgeon were determined to have spawned if they were detected on a receiver near a known spawning site AND BOTH of the following were true:**

- Upstream movement was suspended** with no detections further upstream, **OR** detections were followed by an obvious downstream migration. (Example: A lake sturgeon that migrated upriver to New London and no farther before migrating back to the lakes is considered likely to have spawned).
- Mean Water temperatures** were suitable for spawning (above 50°F) when sturgeon were detected. Rises in water temperature cue spawning.



**Figure 1:** Abacus plot of 12 tagged lake sturgeon during spawning migration and days spent near spawning sites. Tag numbers are on the y-axis and dates are on the x-axis. Colors = spawning sites with acoustic receivers; dots = one day spent at spawning site; bars = continuous days spent at spawning site. The blue line denotes mean daily water temperatures (°F on the y-axis) from the USGS New London Gauge (Wolf River).

- There were two distinct spawning periods in spring 2023. This was very likely due to major temperature fluctuations in April. Only two lake sturgeon are likely to have spawned during the first period which is estimated between April 15 and April 19. Nine of twelve tagged lake sturgeon arrived near spawning sites by April 16 when water temperatures were above 60°F (Fig. 1). However, a 17°F drop in water temperature over the next week likely caused most tagged fish to temporarily leave spawning sites. Some tagged lake sturgeon reappeared at the Shawano Dam and Shiocton during a brief temperature spike around April 29. It wasn't until May when temperatures continued rising above 50°F that the remaining ten lake sturgeon were all detected at spawning sites and probably spawned. The second spawning period is estimated between May 7 and May 9 (Krueger's and Spur Rd) and between May 7 and May 12 (Shiocton and Shawano Dam) (Fig. 1). These dates are confirmed by field sampling efforts in April and May.
- Twelve tagged lake sturgeon are likely to have spawned in spring 2023, including eight males and four females (Fig 1):
  - ⇒ Six at the Shawano Dam (black).
  - ⇒ Three in the Embarrass River (blue and yellow).
  - ⇒ Two at Shiocton had two (purple) and one spawned in New London (grey).
  - ⇒ One spawned in New London (gray).
- Immediately prior to spawning migration, eight tagged lake sturgeon were in Lake Winnebago and one was in the Upriver Lakes. Three are river residents (who remain in the rivers year round).



2023 Lake Sturgeon Acoustic Telemetry Report  
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Upper Fox River Movement Summary

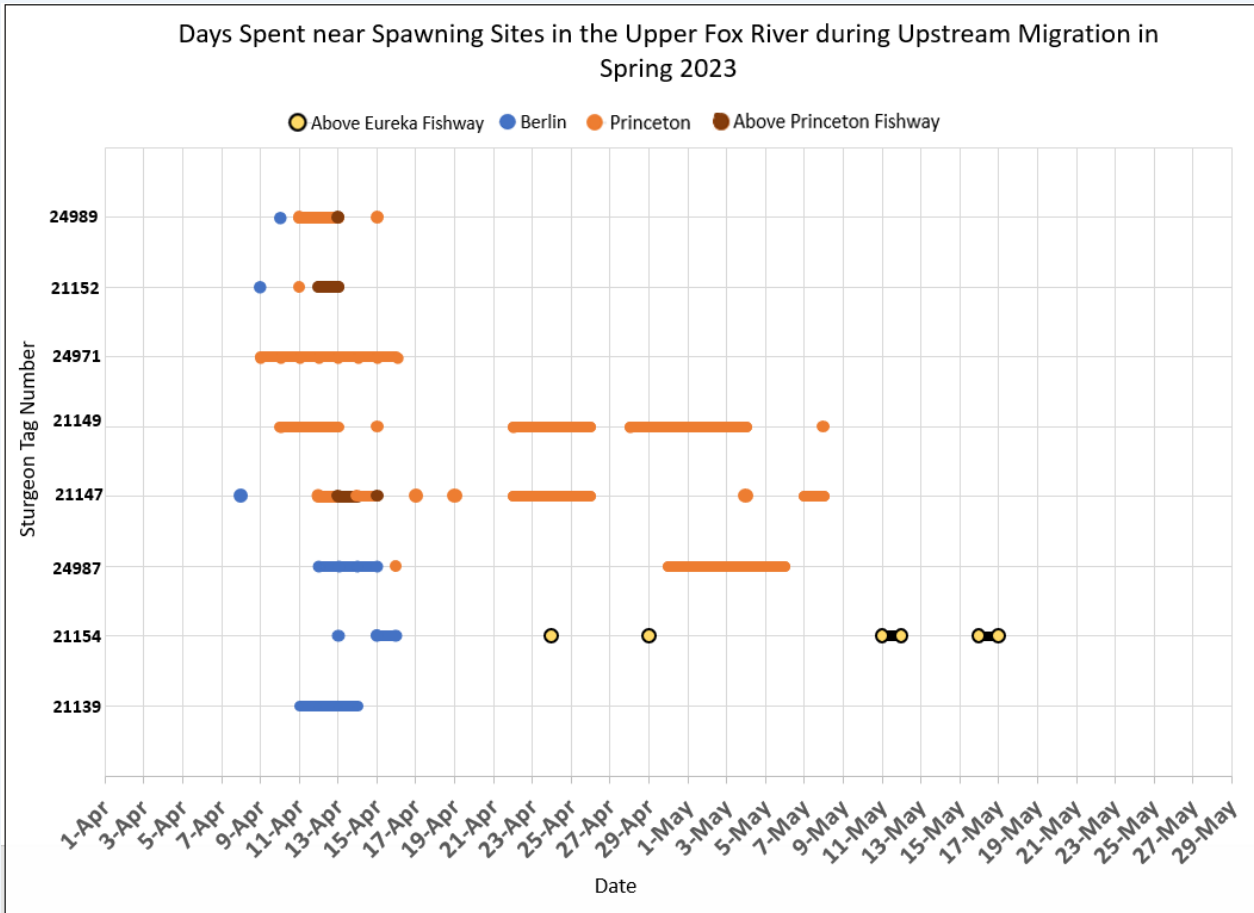


Figure 2: Abacus plot of tagged lake sturgeon that spawned in the Upper Fox River and days spent near spawning sites during their upstream migration. Sturgeon tag numbers are on the y-axis and dates are on the x-axis. Receivers near spawning locations are in color, where dots indicate one day spent and bars indicate continuous days spent.

- Spawning windows are not well known because water temperatures for the Fox River are unavailable. Best estimates are based on the number of days spent near spawning sites and the locations of tagged fish immediately before migrating back downstream.
- Eight tagged lake sturgeon are likely to have spawned in spring 2023, including six males and two females (Fig 2):
  - ⇒ Five at Princeton (orange),
  - ⇒ One in Berlin (blue),
  - ⇒ Two possibly at multiple spawning sites.
- Movement patterns suggest that two spawning periods occurred in the Fox River. This is consistent with field sampling observations in April and May.
- Some lake sturgeon probably spawned only in April. Lake sturgeon numbers 21139 and 24971 likely spawned in Berlin and Princeton between April 9 and April 16 because they left the river soon after. Other lake sturgeon may have waited until May to spawn. Lake sturgeon numbers 21149 and 21147 stayed in the river into May and likely spawned between April 28 and May 8 in Princeton.
- Some lake sturgeon may have spawned in both April and May and at multiple spawning sites. Numbers 21154 and 24987 were detected in Berlin for multiple days in April. By May, both had traveled to a second spawning site where they spent several days. Both lake sturgeon migrated back to Lake Butte des Morts shortly after arriving at those second spawning locations.
- Immediately before spawning migration, six lake sturgeon were in Lake Winnebago and two were in Lake Butte des Morts.



2023 Lake Sturgeon Acoustic Telemetry Report  
Winnebago System

Lake Winnebago Movement Summary

- 37 tagged lake sturgeon did not migrate in spring of 2023. 32 stayed in Lake Winnebago while four others moved periodically between Lake Winnebago and Lake Butte des Morts (Table 4). One lake sturgeon (33920) was not included in spatial analyses due to tag error.
- Most lake sturgeon spent the most time in the Central Zone of Lake Winnebago (Fig.3). Still, each tagged individual displayed unique movement behaviors. 24 lake sturgeon favored the Central Zone, eight spent the most time in the North Zone, and four lake sturgeon favored the South Zone. 87% of lake sturgeon were detected in all zones.

LAKE STURGEON THAT DID NOT MIGRATE UPRIVER IN 2023

Tag Number	Sex	Length at Capture (in)	Tag Date	In Lake Winnebago since (date)
21135	F	66.4	Spring 2018	12/5/2021
21136	F	72.1	Spring 2018	4/12/2021
21140*	F	69.6	Spring 2016	3/28/2023*
21141	F	68.5	Spring 2018	5/10/2022
21145	M	53.2	Spring 2016	5/11/2021
21146	F	66.2	Spring 2016	4/6/2021
21148*	F	62.5	Spring 2016	6/21/2023*
21150*	M	53.7	Spring 2016	3/22/2023*
21153	M	56.1	Spring 2016	5/9/2021
24961	M	56.8	Spring 2015	5/23/2019
24962	M	55.7	Spring 2015	5/19/2022
24966	M	56.4	Spring 2015	6/7/2015
24968	F	60.1	Spring 2015	5/10/2022
24969	M	61.1	Spring 2015	5/2/2022
24975	M	55.7	Spring 2016	5/13/2022
24984	F	69.1	Spring 2016	5/3/2022
24985*	M	47.3	Spring 2016	5/29/2023*
33602	M	56.0	Spring 2013	5/27/2022
33603	F	61.2	Spring 2013	5/8/2019
33607	F	65.5	Spring 2013	12/25/2022
33834	M	56.4	Fall 2012	5/20/2022
33839	F	67.5	Fall 2012	5/30/2022
33859	M	51.8	Spring 2013	5/31/2017
33860	M	54.6	Fall 2013	4/23/2021
33899	M	54.7	Fall 2012	5/1/2021
33907	F	59.4	Fall 2013	5/22/2014
33908	M	65.4	Fall 2013	5/13/2021
33909	M	62.9	Fall 2013	5/11/2021
33911	M	54.8	Fall 2013	9/30/2019
33912	M	59.6	Fall 2013	9/2/2021
33918	M	48.0	Fall 2013	5/25/2020
33922	M	50.0	Fall 2013	5/29/2020
33923	M	47.4	Fall 2013	4/19/2021
33927	M	59.3	Fall 2013	5/29/2020
33929	F	61.5	Fall 2013	5/6/2022
59006	M	56.0	Spring 2018	5/18/2022
33920	M	57.2	Fall 2013	5/18/2022

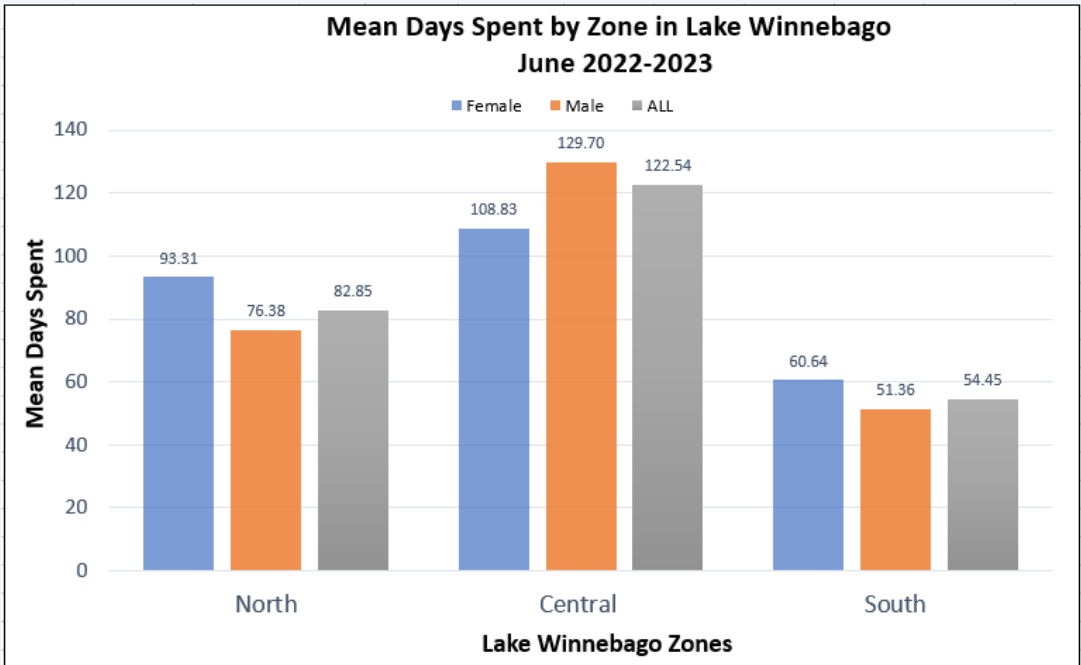


Figure 3: Mean days spent in three zones of Lake Winnebago between June 2022 and June 2023 by 36 lake sturgeon that did not migrate in spring of 2023.

- Mean days spent by zone closely resembles that of chironomid distributions in Lake Winnebago during the 2022 and 2023 chironomid assessments. The relative abundance of chironomids is usually highest in the central and northern regions of Lake Winnebago.
- In 2022, four lake sturgeon left Lake Winnebago and traveled to Lake Butte des Morts between September and December (Table 1). They remained there until the end of March and then returned to Lake Winnebago. Per the 2022 Chironomid Report, Lake Butte des Morts ranked highest in relative abundance of chironomids, while Lake Winnebago ranked the lowest since 2013. These lake sturgeon movements from Lake Winnebago to Lake Butte des Morts may reflect the search for higher prey densities.
- Thirteen tagged lake sturgeon have been in Lake Winnebago since 2022, the year they last spawned. Ten lake sturgeon have been in the lake since 2021, and nine have been in the lake since 2020 or earlier.
- The longest period of time that a tagged lake sturgeon stayed Lake Winnebago without leaving was 3,317 days, or 9.08 years. Female lake sturgeon number 33907 entered the lake on May 22, 2014 and has remained there since (Table 1).
- For males, the longest period of time spent in Lake Winnebago was 2,934 days, or 8.03 years, by number 24966. He entered the lake on June 7, 2015 and has not yet left (Table 1).

Table 4: 37 lake sturgeon did not migrate in spring of 2023 and stayed in Lake Winnebago or traveled between Lake Winnebago and Lake Butte des Morts (\*).