MILWAUKEE RIVER WALLEYE MOVEMENT STUDY USING SONIC TAGGING

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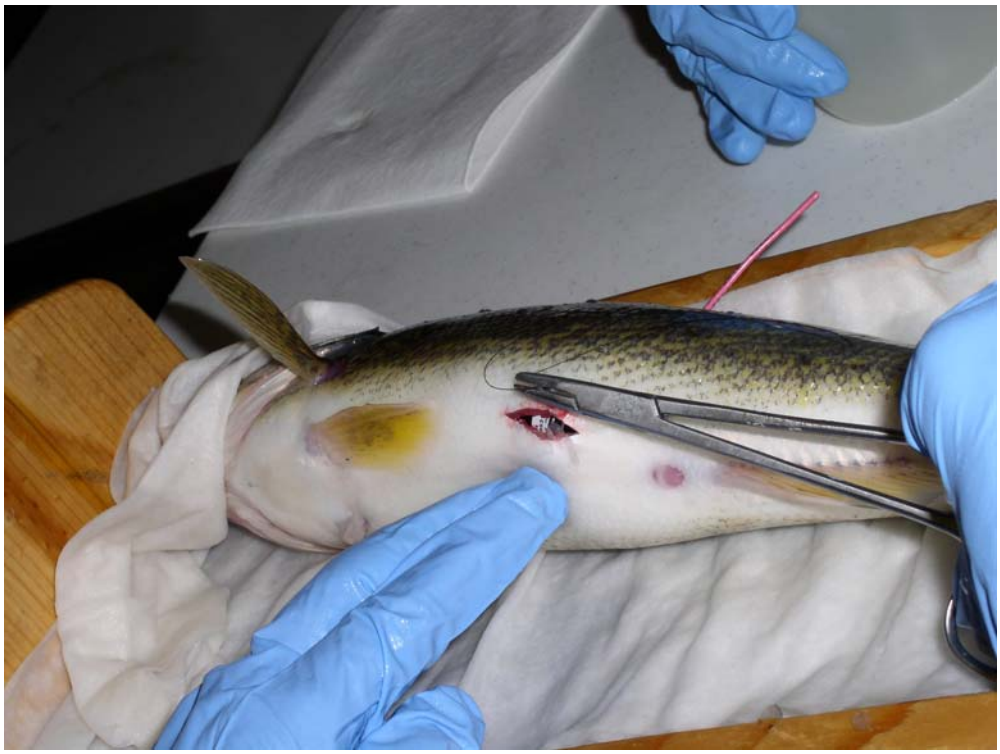

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Background

Walleye are native to the lower Milwaukee River, Menomonee and Kinnickinnic River systems that drain into Lake Michigan at Milwaukee creating the Milwaukee River estuary. Due to construction of dams on these tributaries, industrialization of the area, and agricultural practices in the watershed, the water quality and habitat were severely impaired causing extirpation of the natural population of walleye. In an effort to restore the population, extended growth walleye fingerlings were stocked from 1995 to 2007. Walleye from these stockings survived, grew well and attained maturity. Due to the warmer water temperature in the estuary and abundant food supply these walleye grew faster than the state average and helped create a limited nearshore walleye fishery (Hirethota and Burzynski 2004). However, we were not sure where these mature walleye migrate during the spring spawning season and lay eggs, if they do. A preliminary study was conducted previously by using radiotelemetry to gather their seasonal movement data which can be found in Hirethota and Burzynski (2007). Between spring 2000 and fall 2001 we implanted 41 walleye with duty cycle radio transmitters and collected data until November 2003. A few transmitters provided data for more than two years allowing us to follow through some walleye for more than one spawning cycle. Preliminary results from this study indicated a distinct seasonal movement pattern in adult walleye where in the fish moved upstream in spring which coincided with spawning period. Although our initial attempt using the radio telemetry provided a general pattern of movement of adult walleye in the lower Milwaukee River, the data was lacking on the specific timings, fixed locations and duration of stay in an area. Hence, we embarked on using a sonic tagging study with receivers located at fixed stations to obtain more specific information on the movement of adult walleye. Also, sonic tagging study is less labor intensive than radio tracking and provides more time-specific data.

Objectives

The main objectives of this study were to: a) identify the timing of spring migration, b) identify potential locations of spawning areas for walleye in the lower Milwaukee River, and c) to determine if home ranges exists for walleye in the Milwaukee River estuary.

Methods

We surgically implanted ten adult walleye (5 males and 5 females) captured in the lower Milwaukee River and harbor (Figure 1) with sonic tags (Vemco model V13-1L-A69-1303) in March 2010 prior to the onset of upstream spawning migration (Hirethota and

Burzynski 2010). Walleye generally spawn in the spring when the water temperature attains 42-46º F. The tags were programmed by the manufacturer to perform for 797 days which could encompass two spawning seasons. The tags measured 32 mm and weighed 6 grams in water. The data on their movement were recorded by installing receivers (Vemco® model VR2W 69 kHz; Figures 2 and 3) at various locations in the study area (Figure 1) for continuous recording of tagged walleye. All ten mature walleye (ranging from 411mm to 587mm) were implanted on March 24, 2010. Five walleye were released upstream just below the former North Avenue Dam on the Milwaukee River, and the remaining five fish were released in the Menomonee River and canals (Figure 1).

Surgical procedure:

Adult walleye were captured using a DC boat electroshocker and transported via WDNR boat to the University of Wisconsin – Milwaukee, School of Freshwater Sciences (SFS) facility. Walleye were placed in a large flow-through tank installed on the dock at SFS to recover from the stress of shocking and transportation. A few large chunks of salt were added to the tank to help recover the loss of salt/electrolytes. Each walleye was anaesthetized in a separate tank using carbon dioxide (personal communication – Sue Marcquenski, Fish Health specialist, WDNR). The anaesthetizing tank was continuously monitored for dissolved oxygen and pH levels using a Hanna Instruments HI® 9811-5 multifunction meter. The pH level was adjusted using baking soda to maintain the initial water pH at time of capture. Surgical instruments, sutures and sonic transmitters were disinfected in Nolvasan® solution. Once fish equilibrium was lost, the fish was carefully removed in a sling net, weighed, measured and placed on the surgical table. The site to make an incision on the body was dried and wiped with Carravet® gel. Using a sterile scalpel and grooved director, an incision (approximately ¾ inch) was made in the fish's abdomen slightly lateral to the ventral midline. While performing the surgery the gills were kept constantly irrigated with fresh water using a squirt bottle. Prior to inserting the tag into the fish body cavity the sonic transmitter was removed from the Nolvasan® solution and rinsed with sterile water. The incision was quickly closed using 3-4 sutures of 3-0 Ethilon black mono nylon, 18" cutting needle PS-1 (Figure 2). Injectable oxytetracycline 200 mg was dispensed along the incision line and at the suture points to help protect from infection. The process from the time of making incision to closing with sutures took approximately four minutes. Further, each fish was tagged with a numbered Floy® tag with DNR office address and implanted with a PIT tag. After the surgery, the fish were transferred to a circulating water recovery tank with 0.5% to 0.9% salt solution. The fish were held in the recovery tank for 45 minutes to 1 hour before transporting them to the release locations.

Table 1. Data on walleye that were implanted with sonic tags on 3/24/2010 and released in the Milwaukee River and harbor.

Fish ID#	Total length (mm)	Weight (g)	Sex (M/F)	Capture and Release location	Dates of first and last detection	# of days detected at large
620	541	4500	F	Menomonee River	3/30/10-3/31/10	2
621	550	4500	F	Menomonee River	3/28/10-4/13/10	17
622	434	3000	F	Menomonee River	3/25/10-3/26/10	2
623	486	1900	F	Menomonee River	3/28/10-4/10/12	745
624	411	1100	M	Menomonee River	4/2/10-10/11/11	558
625	535	2200	M	Milwaukee River	3/24/10-5/26/12	795
626	455	1200	M	Milwaukee River	3/24/10-4/17/10	25
627	587	2750	F	Milwaukee River	3/24/10-4/21/10	29
628	424	1250	M	Milwaukee River	3/24/10-4/28/11	401
629	443	1200	M	Milwaukee River	3/24/10-6/15/11	449

Data gathering and analysis:

The process of continuous data gathering on the movement of tagged walleye was accomplished by installing a series of acoustic telemetry receivers (Figures 2 and 3) at various locations in the lower Milwaukee River and the harbor (Figure 1). Deployment time at a location varied based on changes in desired coverage area and environmental conditions. The data were downloaded to a laptop computer for compiling and analysis using VUE (Vemco User Environment; Version 2.0.6-20130212) software. Because of the cost, we had to move around some of the receivers in order to cover a wider coverage area. Therefore, not all of the sites had the advantage of having a receiver for the entire study period. Also, some of the receivers were lost due to ice, vandalism or malfunctioning. The sonic tags were designed and built to transmit for 797 days, which would potentially provide two consecutive years of movement data. Signs informing anglers about the study were posted at several locations throughout the study area so that if a tagged fish was caught they might release them.

All data were exported from the VUE software into Excel files for analysis. Data files were also imported into ArcGIS for generation of movement and distribution maps.

Results

On March 24, 2010 a total of ten adult walleye were implanted with sonic tags and released (Table 1). In this study the last time a fish was detected and registered on the receiver was on May 26, 2012 which is about two years and two months (795 days). Of the ten fish, walleye 620 and 622 were detected for only two days following release (Table 1). Of the remaining eight tags, three tags were detected for 17 to 29 days only and five tags were detected anywhere from 401 to 795 days. One of the tagged walleye was caught by an angler on July 7, 2011 (449 days total) who returned the tag to WDNR.

The following is the detail account of five of the walleyes that were tracked for one year or more starting with the one that was detected for the longest time.

Walleye 625

In March 2010 seven receivers were deployed (Table 2). Three of them were deployed from March 24, 2010 through September 27, 2010 at locations – Menomonee River/MMSD (off of MMSD – Milwaukee Metropolitan Sewerage District office), Spawning reef and Milwaukee outer harbor outside the Summerfest Lagoon. The other three were deployed from March 24, 2010 through May 17, 2010 at locations – Chambers Street, Estabrook Falls, and Estabrook Dam, and one inside the Summerfest Lagoon from March 24, 2010 until June 2010.

Walleye 625 was a ripe male captured and released in the lower Milwaukee River below the former North Avenue Dam. It moved to the spawning reef area and further upstream in April and spent a brief time (12 days) at Estabrook Falls and then returned to the spawning reef later in April and then down to the Menomonee River. In May it moved to the outer harbor and then moved back to the Menomonee River area, and again moved to outer harbor (Figure 5). Later in the winter the fish was detected in the Summerfest Lagoon on Jan 6, 2011 (Figure 6). The fish moved back and forth between the lagoon and the Menomonee River from January through April, 2011. In the spring 2011 the walleye was detected upstream on the Milwaukee River at Chambers Street on May 6, 2011 and at the Spawning Reef on May 21, 2011. The fish then moved downstream to the Menomonee River on May 22. It stayed for an extended time around the North Swing Bridge and Menomonee River from July 8th through mid-October. It was detected in Summerfest Lagoon on October 16, 2011, moved out to Veteran's Park briefly and back to the lagoon (Figure 6). Throughout the fall, the fish moved freely between the lagoon and the Menomonee River, and was last detected on May 26, 2012 near the North Swing Bridge. Even though we had a receiver at the spawning reef in the spring 2012, we did not have any detection of this walleye. It appears that walleye 625 moved around quite a bit through the harbor, utilized the lagoon and the Menomonee River and the confluence during the winter and the fall. In 2011 spring it went back to the spawning reef and up further to Chambers Street, and later returned to the harbor. Walleye 625 was last detected on May 26, 2012 for a total of 795 days at large in the system which was the longest time a walleye was detected in this study (Figures 5 and 6).

Walleye 623

Walleye 623 was a mature female which was captured and released in the Menomonee River and canals on March 24, 2010. It was first detected in the Menomonee River on March 28, 2010. Then on April 16th the fish moved from the Menomonee River and canals to the spawning reef in approximately 13.25 hours (0.32 km/hr). Most of the time, this fish travelled at night to distant locations. It moved back to Menomonee River on the 18th in 10.28hrs, an average speed of 0.42 km/hr. It then moved back upstream to the spawning reef on May 2, 2010 (8.25hrs; average speed 0.52 km/hr). The fish moved back and forth between these two areas several times through mid-June. On June 26, 2010 it was detected at the outer harbor, and back again at the spawning reef on July 11, 2010. It came back to the outer harbor on August 18, 2010 and stayed until September 19, 2010. It seems the fish overwintered in the Menomonee River since it was detected there on Jan 5, 2011. It was detected in March, April and until May 22, 2011 near MMSD and Riptide and then on May 25, 2011 it went to the spawning reef. It stayed there for two days and then moved several times between Menomonee River and the spawning reef until June 21, 2011. Later in the fall it was detected at Veterans Park on September 30, 2011 until October 15, 2011 when it moved to the North Swing Bridge. The fish moved between the North Swing Bridge, Summerfest lagoon, Menomonee River and Veterans Park in November-December. On February 29, 2012 the fish moved upstream to the spawning reef and remained there until March 9, 2012, when it moved to the Summerfest lagoon. On March 12, 2012 it moved to the spawning reef. It was next detected at Estabrook falls on March 19, 2012. The fish moved out to the Summerfest lagoon on April 8, 2012. The last detect was in the Kinnickinnic River on April 10, 2012 (749 days after release). That means the fish moved around quite a bit (Figures 7-8 – walleye 623) yet it seems to have a well-defined range. In 2010 it moved upstream in early May, where as in 2011 it went to the spawning reef in late May and continued to show up until June 21, 2011. In 2012 the fish went upstream as early as end of February, but stayed around there through most of March.

Walleye 624

This male walleye was caught and released in Menomonee River on March 24, 2010 and was last detected on October 11, 2011 for a total of 567 days at large in the system. It was first detected on April 1, 2010 in Menomonee River/MMSD area where it stayed until May 17, 2010. It was then detected at the spawning reef on June 11, 2010 and on June 12, 2010. It moved back to Menomonee River on June 13, 2010 and stayed there all of summer, fall and early spring of 2011. It was detected again the following spring on May 4, 2011 and May 5, 2011 at Chambers Street and the spawning reef. On May 7, 2011 walleye 624 was back in the MMSD area and remained around the North Swing Bridge and MMSD area throughout the fall. Even though we could not track this walleye beyond October 11, 2011, it showed a clear preference to Menomonee River/MMSD and North Swing Bridge area to spend the fall and winter, and a short visit upstream in the spring (Figures 9-10, –walleye 624).

Walleye 629

This was a male walleye captured and released upstream below the former North Avenue Dam. It was first detected near the spawning reef on the day of release (3/24/10) and then it moved down to the MMSD area on March 27, 2010 where it stayed until June 12, 2010. Then it moved out to the outer harbor where it was detected on June 18, 2010 and stayed there until July 23, 2010, and then it moved all the way up to the spawning reef on July 25, 2010 where it was detected until September 4, 2010. The next detection of this walleye was on January 8, 2011 at MMSD. It probably over wintered in that area as it was detected near Riptide on March 18, 2011 and March 22, 2011. It seems that walleye 629 made a short trip to Summerfest lagoon as it was detected there on March 23, 2011 and then back at Riptide/MMSD area on March 25, 2011. It stayed there until April 8, 2011 and the next detection was upstream at Chambers Street on May 5, 2011 and returned to Menomonee River/MMSD on May 5, 2011 where it was detected for the last time on June 15, 2011 (Figures 11-12 – walleye 629). Although it was detected at Chambers Street on May 5, 2011, the downstream receiver at the spawning reef seems to have missed it. It is possible that the fish may have been moving upstream along the opposite bank. This walleye was harvested by an angler on July 7, 2011.

Walleye 628

Walleye 628 is another male walleye that was captured and released upstream below the former North Avenue Dam. It was first detected on April 1, 2010 at Estabrook Falls and then moved downstream to the spawning reef area where it was detected on April 28, 2010. Then it went down to Menomonee River/MMSD area where it was detected on May 24, 2010, but moved back upstream to spawning reef on May 24, 2010. In July it was detected in Menomonee River. It seems the fish spent most of August at the spawning reef, but rest of the fall and early spring was spent near MMSD and Riptide where it was detected from September 5, 2010 until March 23, 2011. It is unclear what kept this walleye upstream during most of August. From March 23, 2011 to April 12, 2011 this walleye made several back and forth trips between Riptide area and Summerfest lagoon. It travelled upstream to spawning reef in mid-April (4/13/2011). It was last detected on April 28, 2011 at Chambers Street which is upstream of the spawning reef site Figures 13-14 – walleye 628).

All five tagged walleye combined

Movement results of these five walleye collectively are presented in the figures 15 and 16 for 2010 and 2011, respectively. The tagged walleye spent the majority of the time in March, April and May of 2010 in the upstream sections of the Milwaukee River near the spawning reef and Estabrook Falls. Whereas in June, July and September, the majority of the time they were in the outer harbor and near MMSD in the Menomonee River. We did not have receivers deployed in October, November and December of 2010. In 2011, the majority of the time the tagged walleye were found in the inner harbor, Menomonee River/MMSD and Summerfest Lagoon from January through April. However, they started appearing upstream in April, May and June. And from July through September

they are exclusively in the inner harbor near MMSD and the North Swing Bridge, later they shared time between the inner harbor and Veteran's Park in October and November. Only two walleye tags were detected in the spring of 2012 of which one walleye (Walleye 623) returned upstream in early spring and then moved to the harbor.

Table 2. Deployment of sonic tag recievers in the lower Milwaukee River and harbor, 2010-2011.

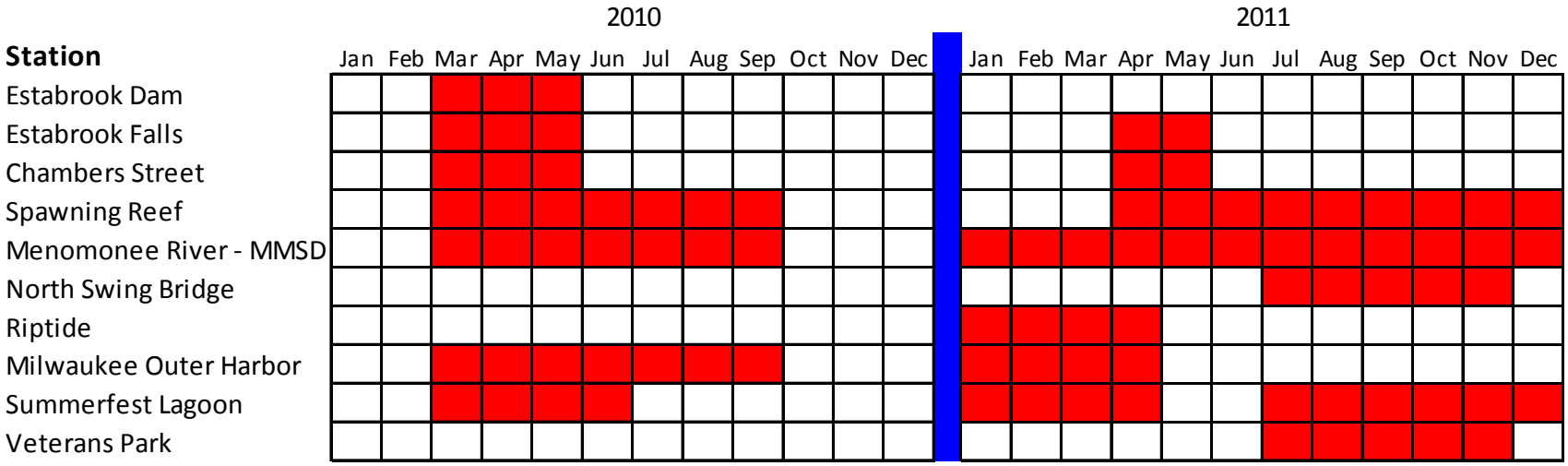

Figure 1. Map of study area with sonic receiver locations. Capture and release locations are shown on the map.

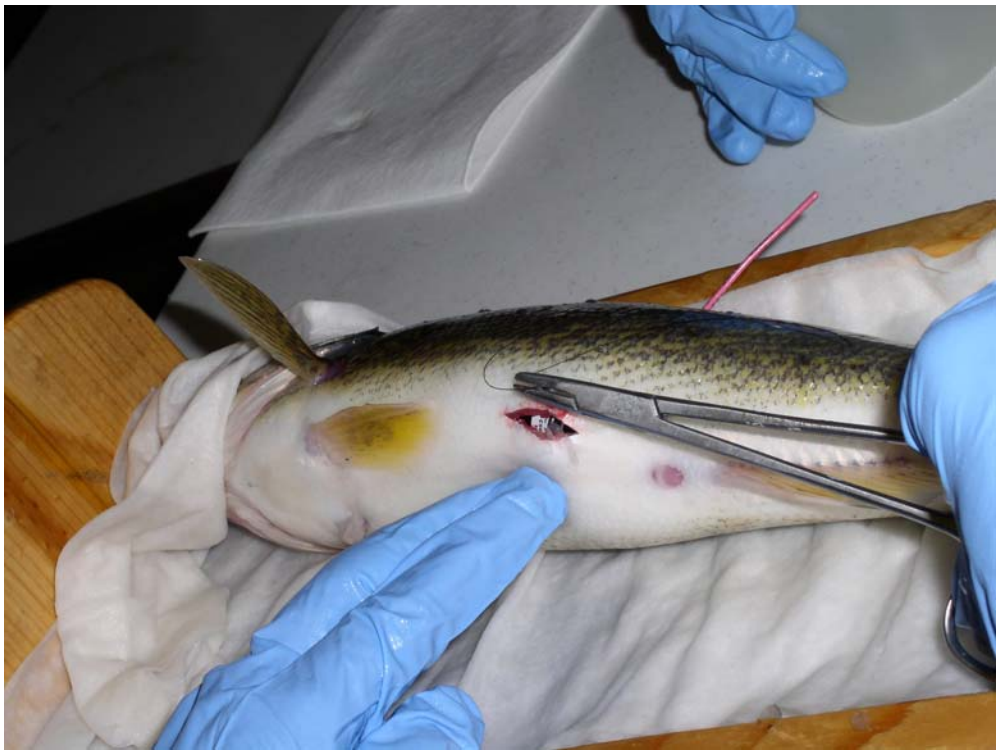

Figure 2. Sonic tag implantation procedure. Each fish also individually marked with a Floy® T-bar anchor tag and a PIT tag.

Figure 3. Sonic telemetry receiver with Bluetooth data download key inserted.

Figure 4. Typical bottom-deployment setup for the VEMCO receiver with galvanized pipe and PVC.

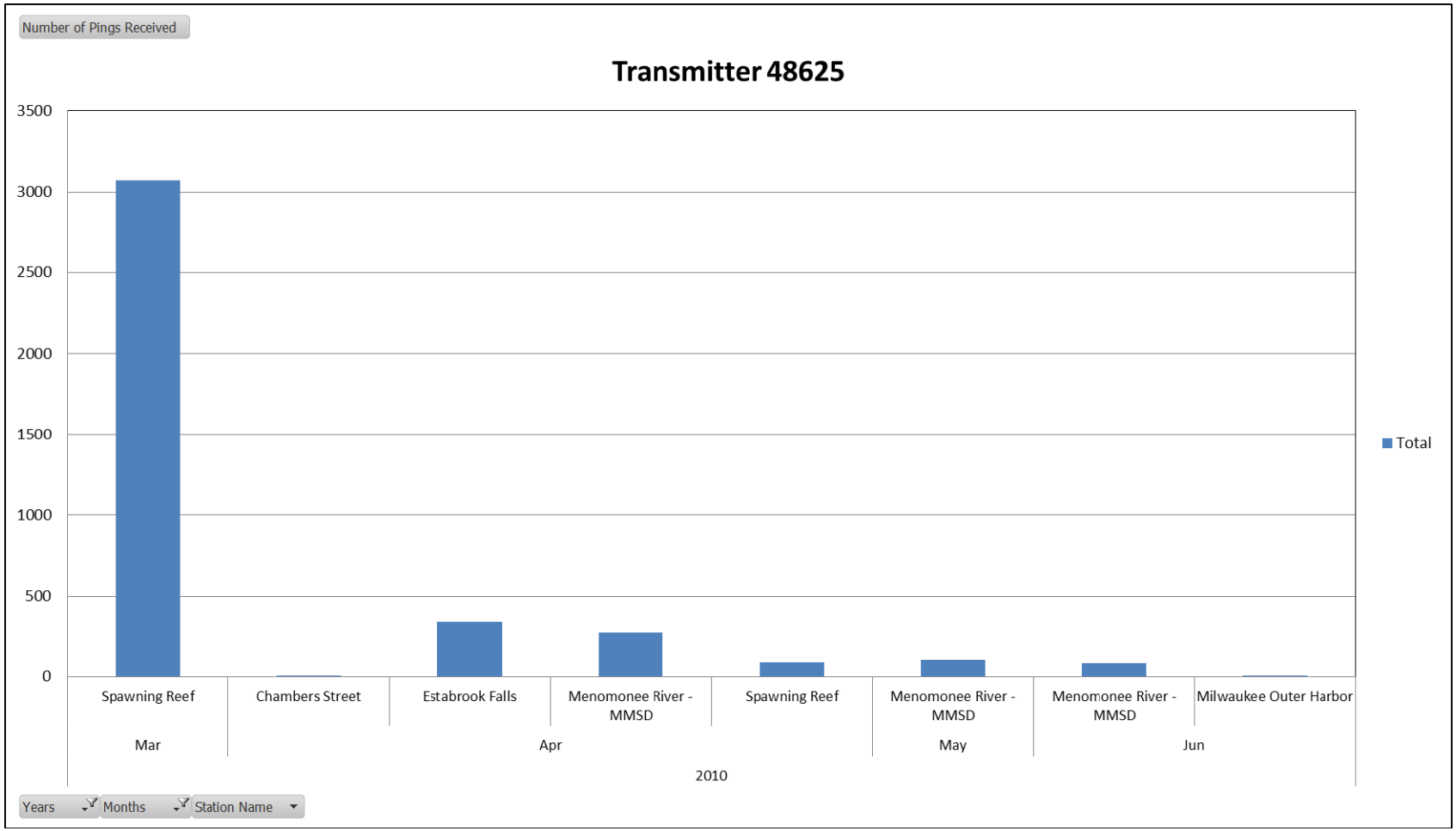

Figure 5. Movement of walleye 625 in 2010.

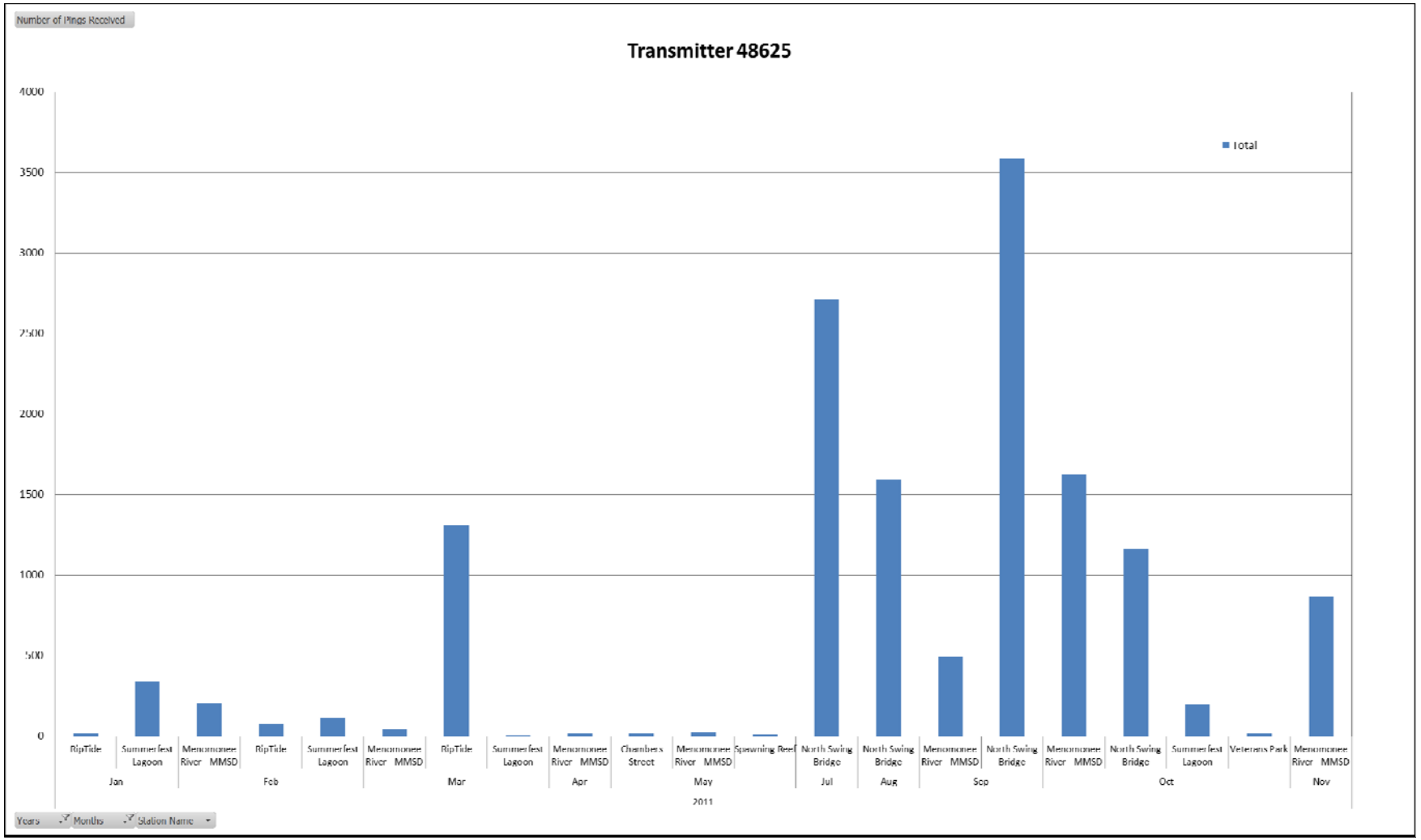

Figure 6. Movement of walleye 625 in 2011.

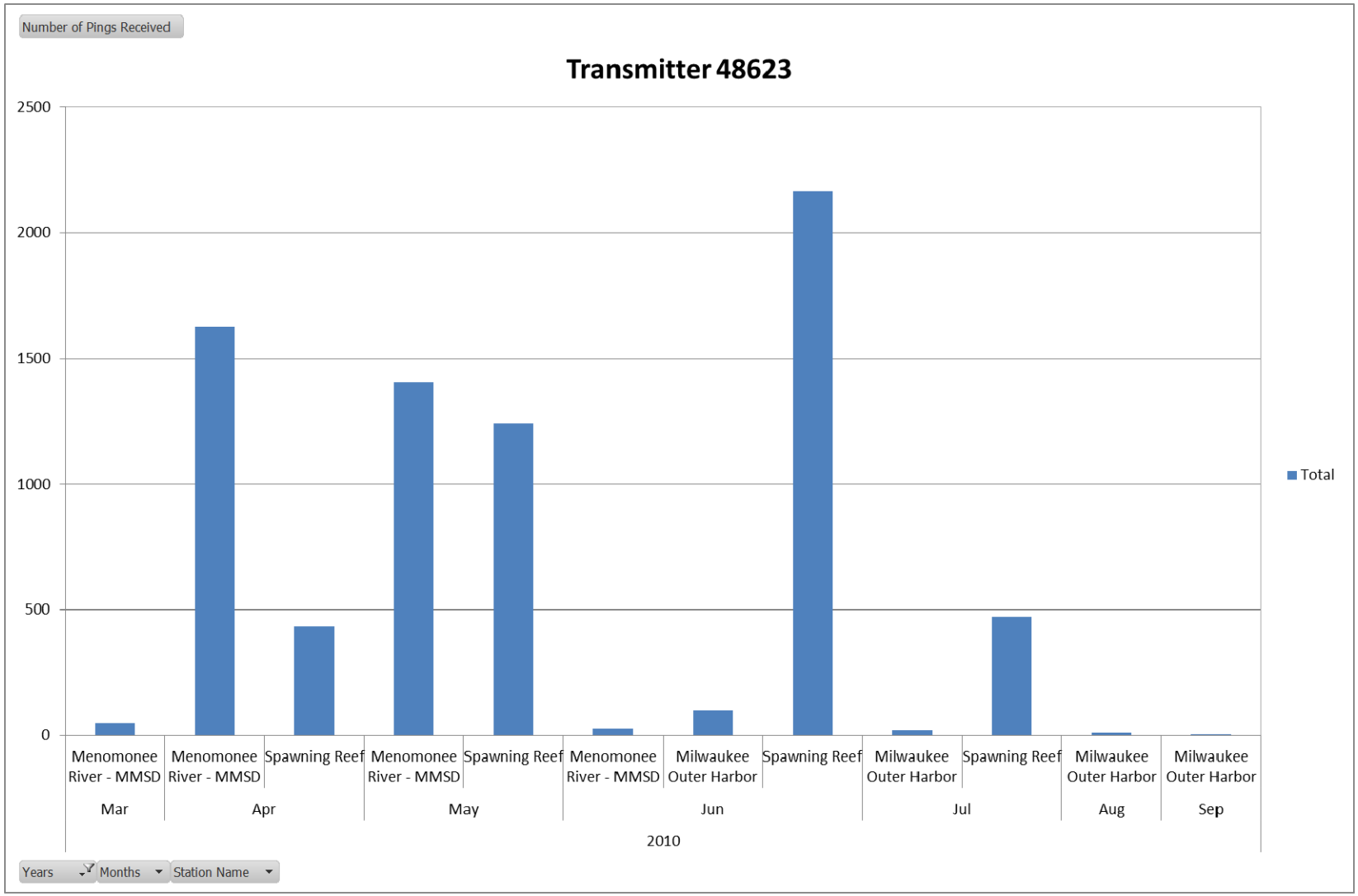

Figure 7. Movement of walleye 623 in 2010.

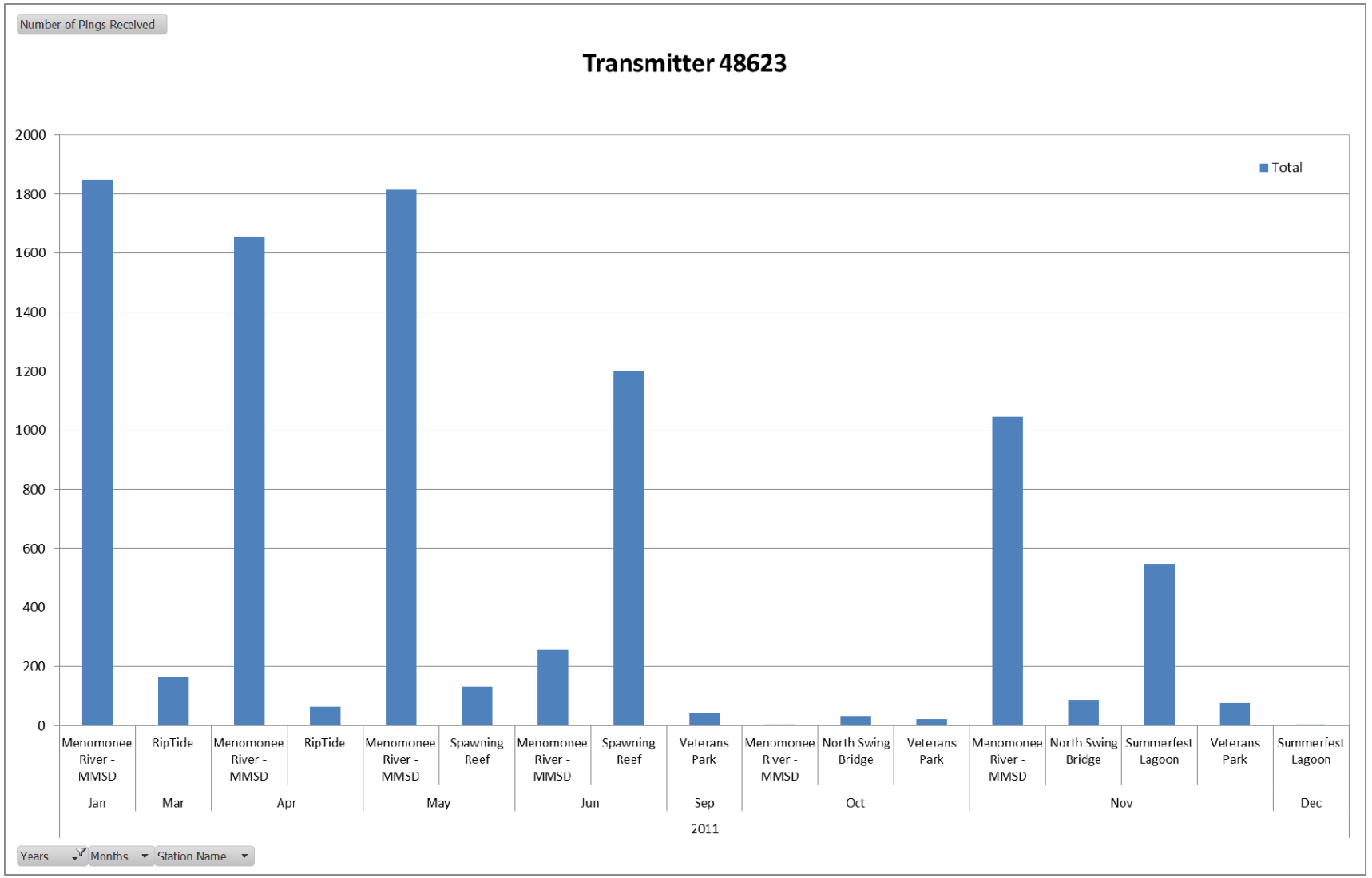

Figure 8. Movement of walleye 623 in 2011.

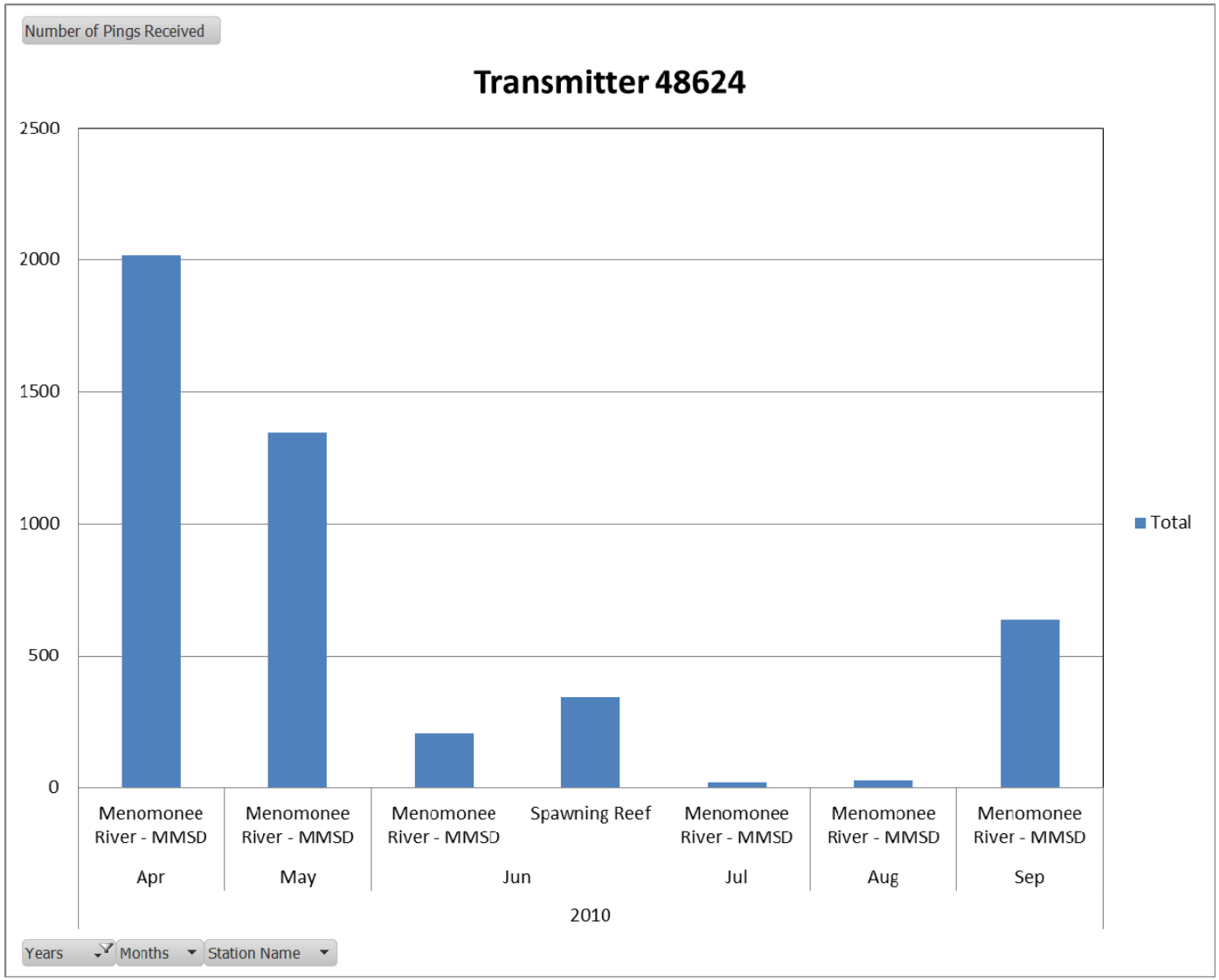

Figure 9. Movement of walleye 624 in 2010.

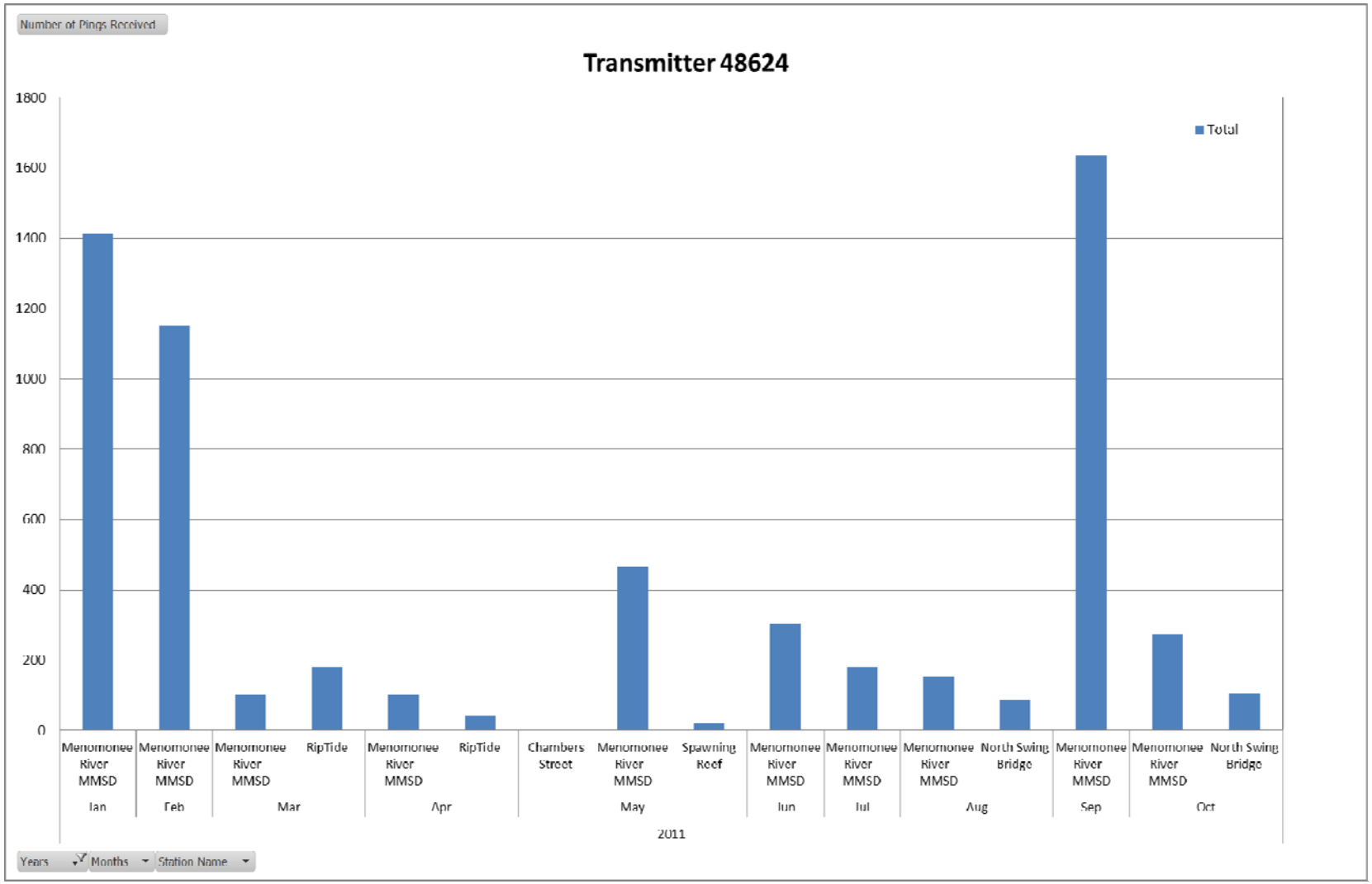

Figure 10. Movement of walleye 624 in 2011.

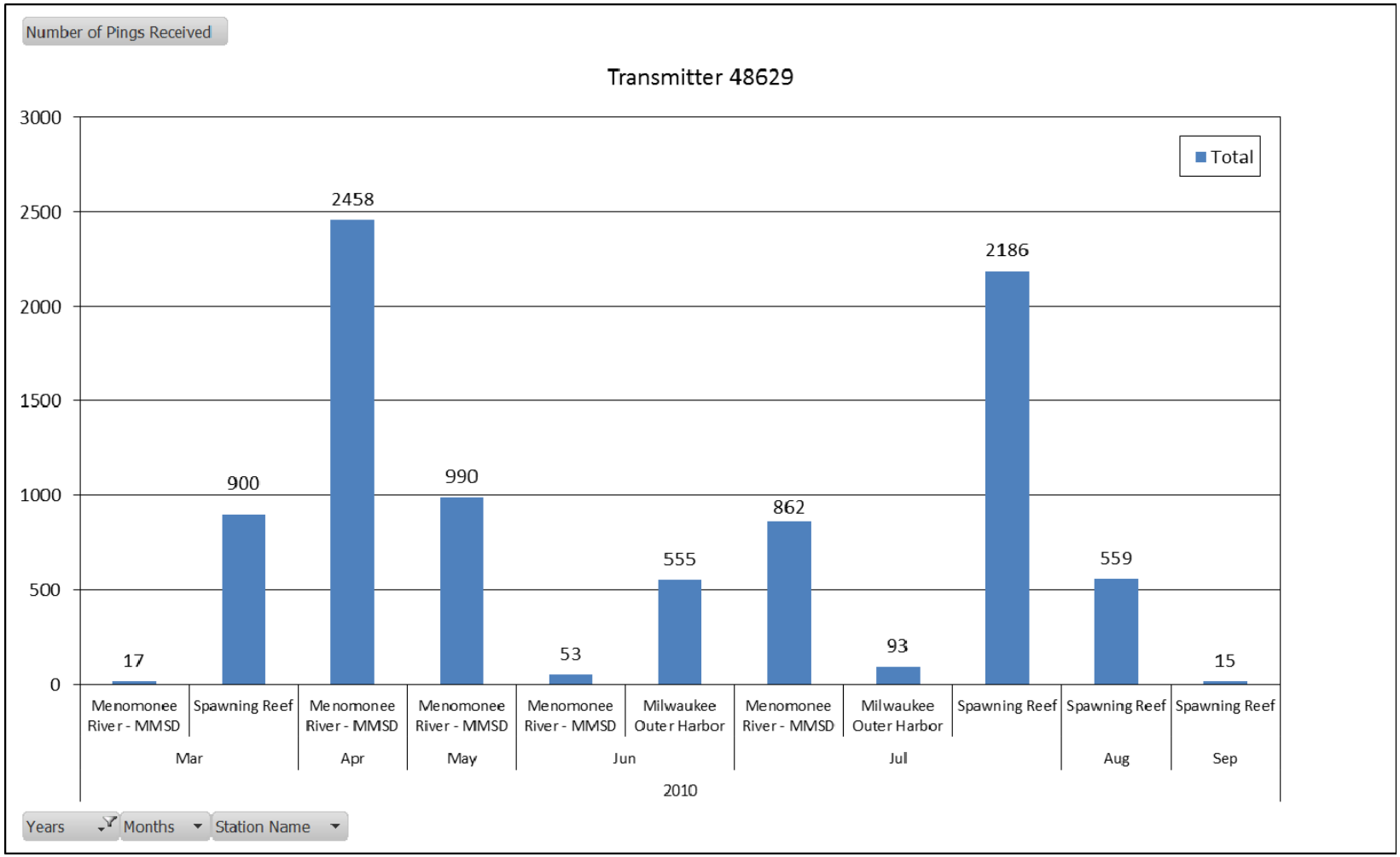

Figure 11. Movement of walleye 629 in 2010.

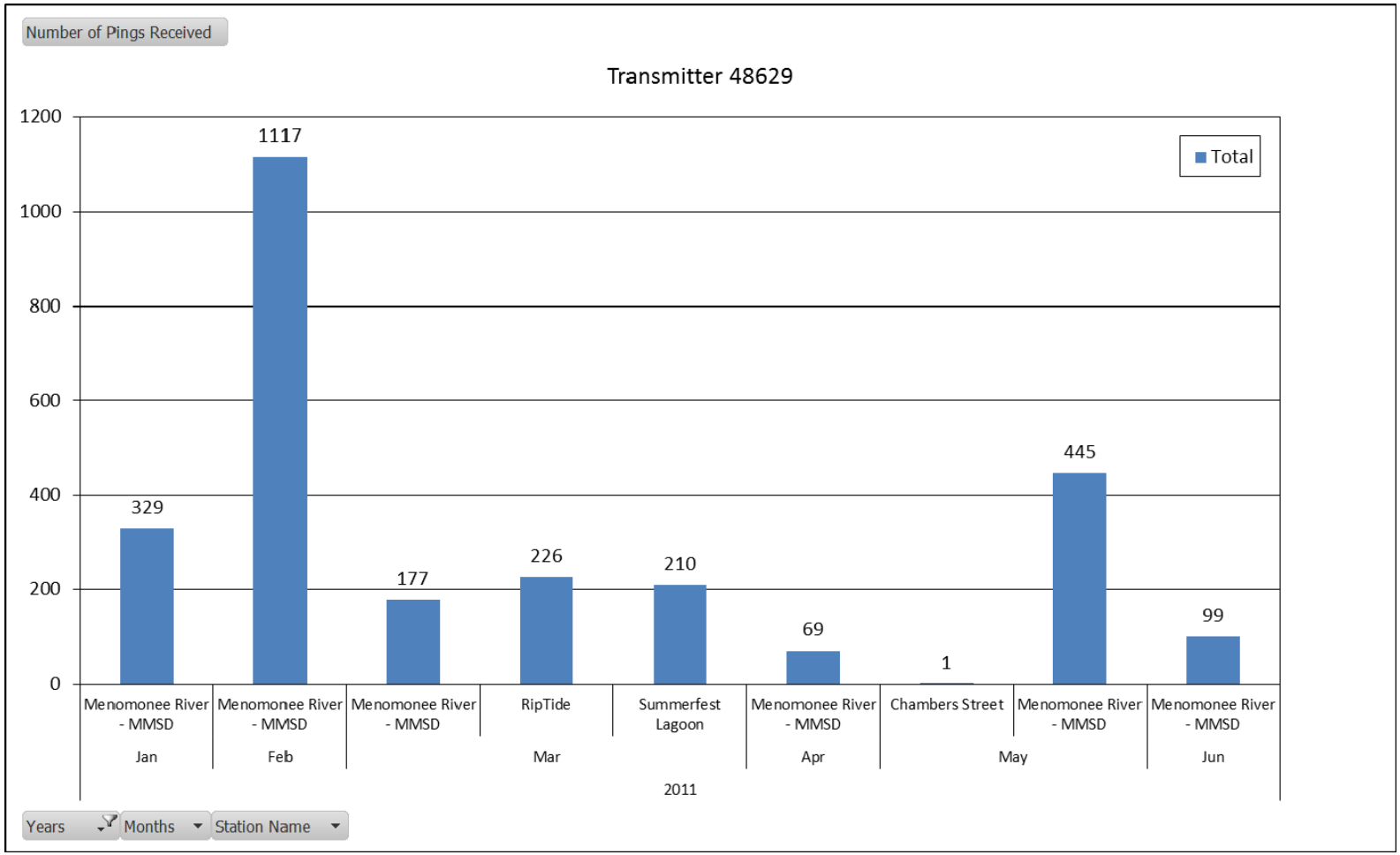

Figure 12. Movement of walleye 629 in 2011.

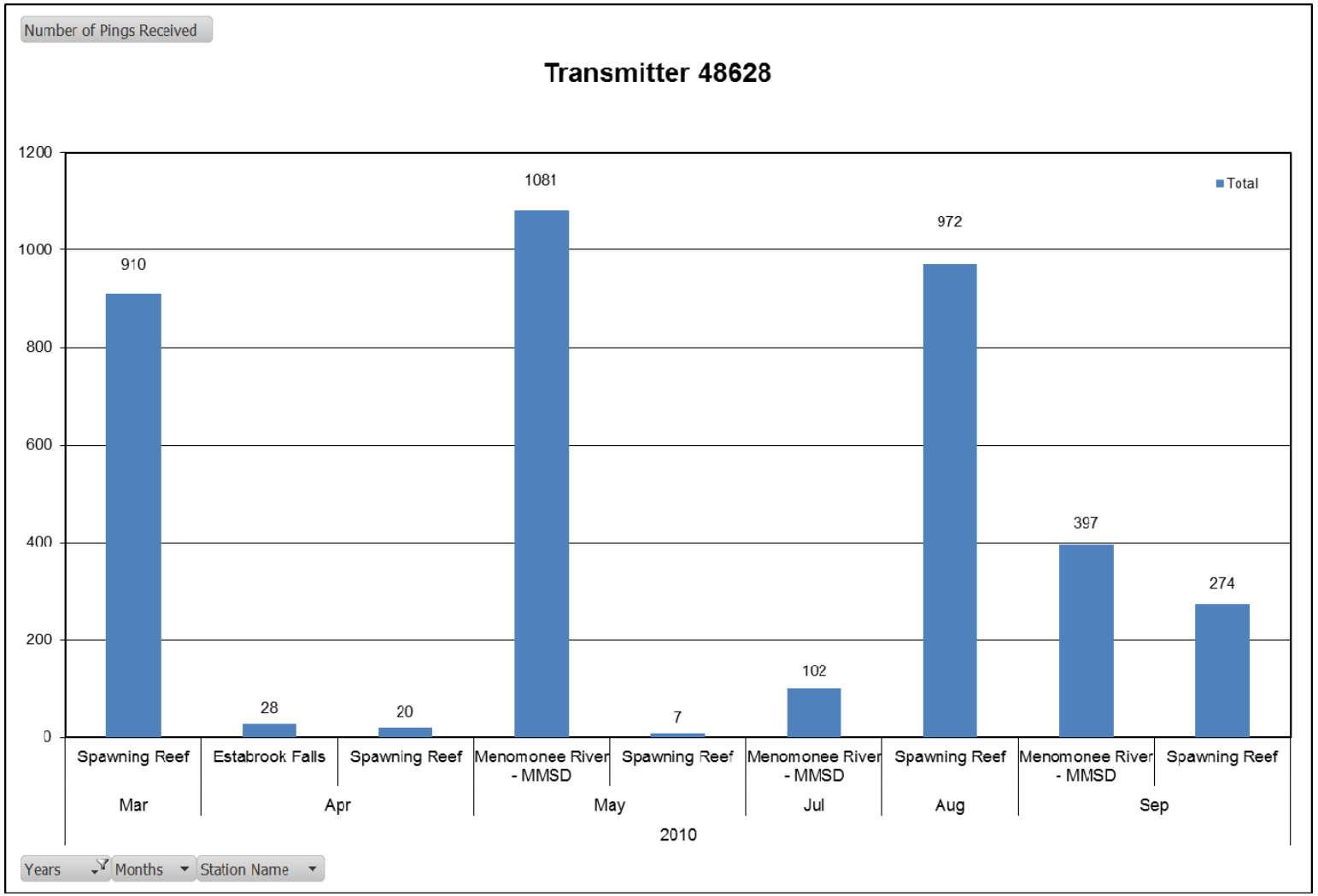

Figure 13. Movement of walleye 628 in 2010.

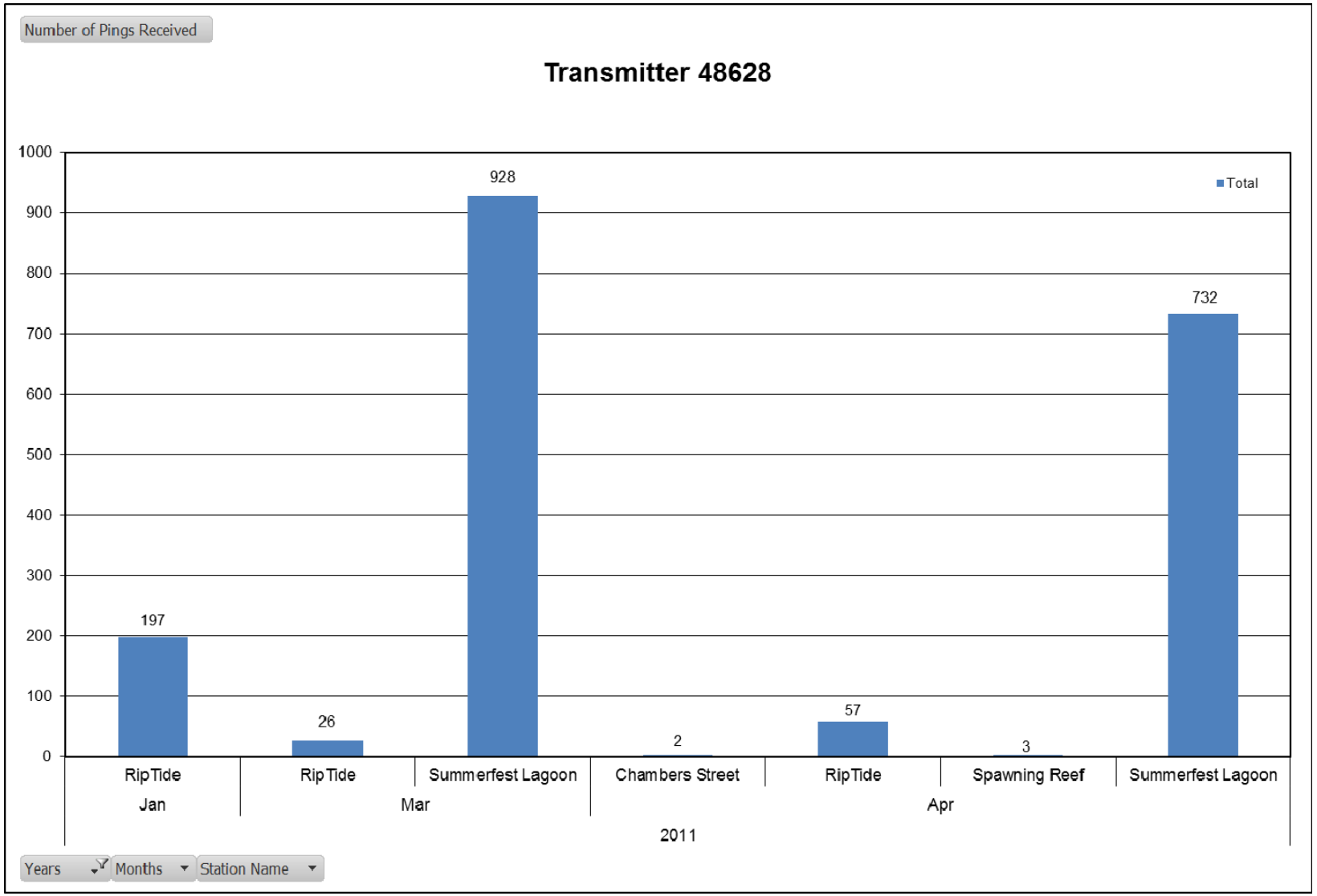

Figure 14. Movement of walleye 628 in 2011.

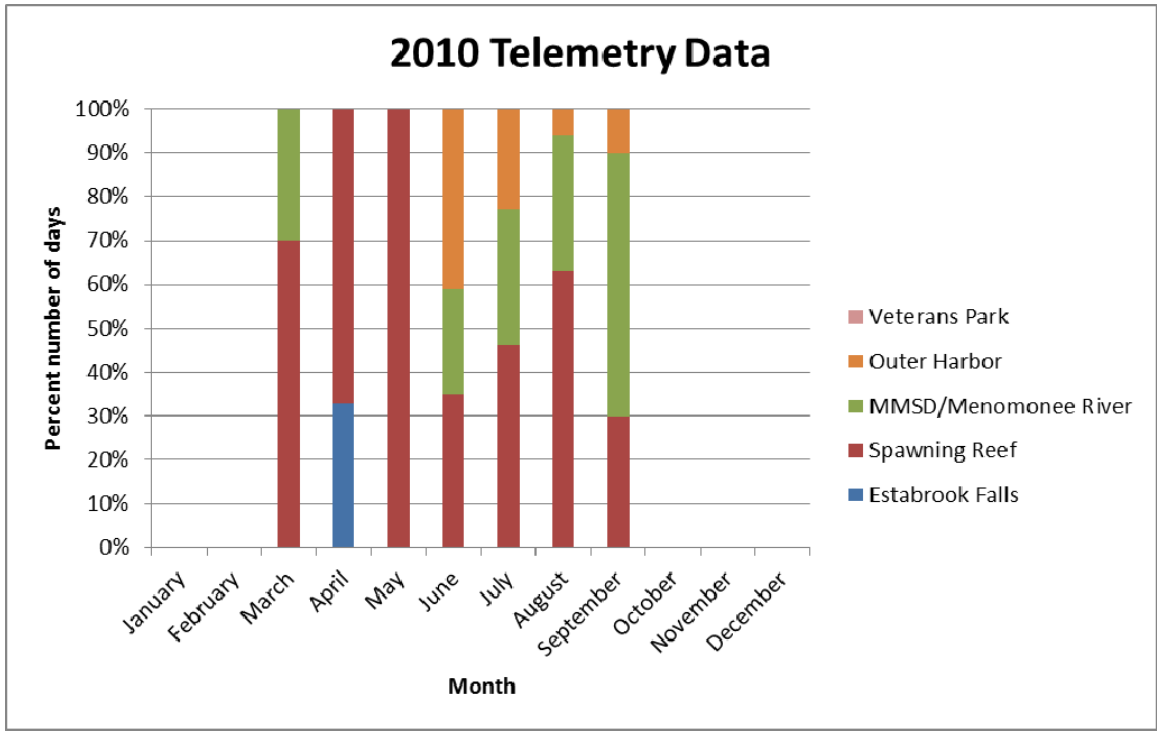

Figure 15. Summary of the movement pattern of five sonic tagged walleye in the Milwaukee estuary in 2010.

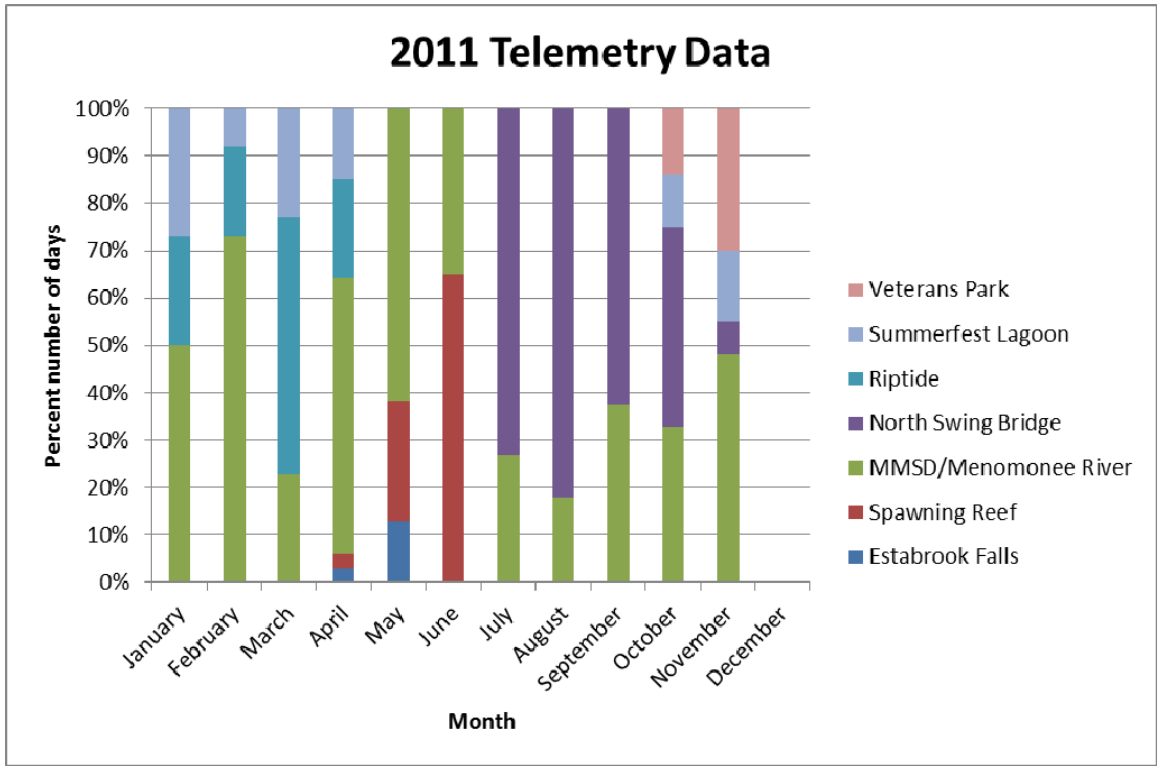

Figure 16. Summary of the movement pattern of five sonic tagged walleye in the Milwaukee estuary in 2011.

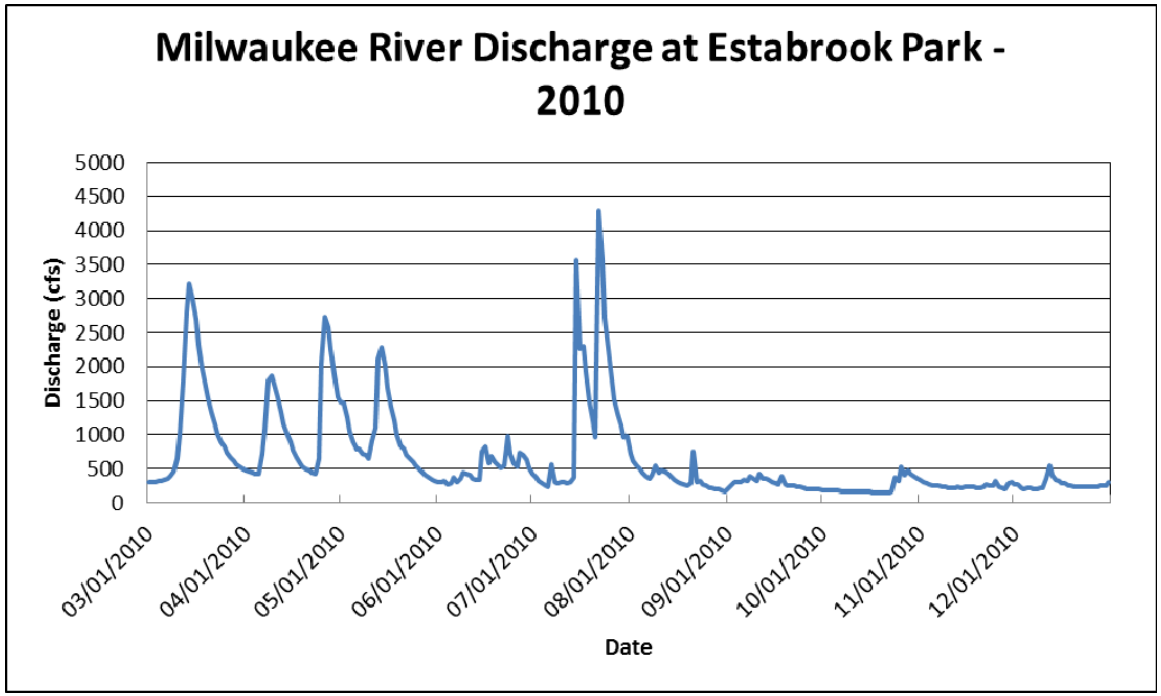

Figure 17. Average monthly discharge of Milwaukee River in 2010.

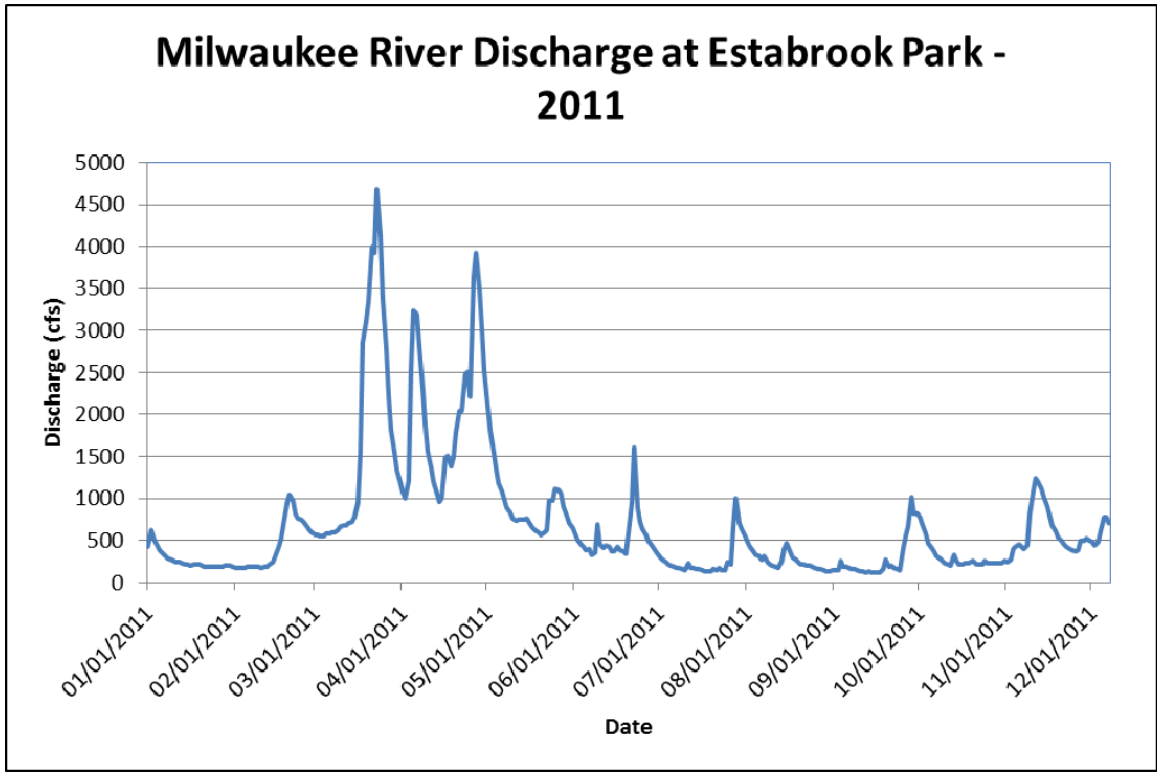

Figure 18. Average monthly discharge of Milwaukee River in 2011.

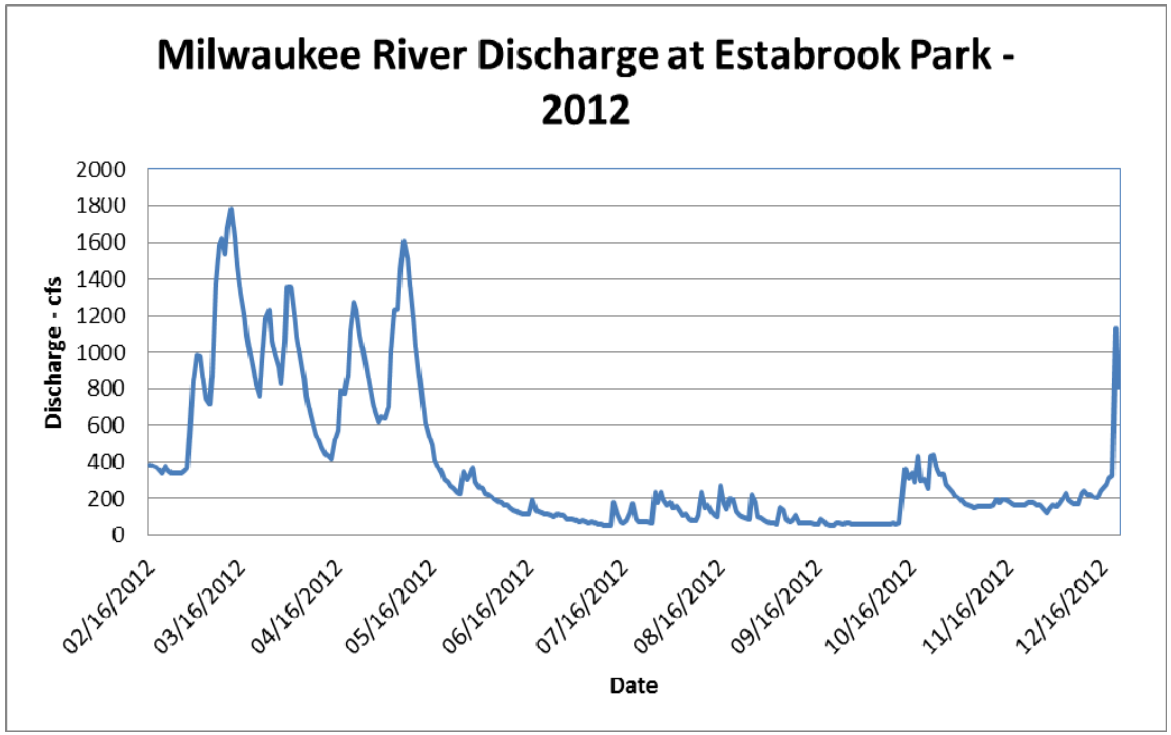

Figure 19. Average monthly discharge of Milwaukee River in 2012.

Discussions

A general seasonal movement pattern was revealed using sonic tags for walleye in the lower Milwaukee River and harbor. Overall, data from five tagged walleye indicated that walleye made frequent trips up the Milwaukee River to locations near the former North Avenue Dam during the spring, presumably for spawning. The seasons may be categorized as spring for the months of April, May and June. All five walleye that were tagged in spring 2010 and tracked longer than a year returned to the Milwaukee River to the spawning reef in spring 2011. The amount of time each fish spent at any location varied. In 2010 much of the time post spawning which included the summer, fall and winter, they prefered to stay in the deeper outer harbor waters in late summer, but around MMSD and the North Swing Bridge in September and in early 2011. The previous study using the radio telemetry (Hirethota and Burzynski 2007) revealed that the majority of radio detections occurred in the upstream waters in the spring while the majority of radio detections occurred in the harbor later in the summer. Our current observations using sonic tagging reinforces the previous findings. There is a clear pattern in 2011 data (Figure 16) that walleye travel back to the harbor waters post spawning for feeding, and continued to stay throughout the fall and winter. The Milwaukee inner harbor remains warmer in the winter, and also there is substantial prey fish available for walleye to feed during this time.

Hayden et al (2014) observed spawning site fidelity in Lake Huron walleye that returned to the Saginaw River in the following year. In their study about 64% of tagged walleye returned to the Saginaw River in the following spring. Also, Hanson (2006) in his study on walleye movement in the Muskegon system reported walleye moved to Muskegon River during March, April, and May. Majority of the tagged walleye in their study spent June through August in the lacustrine habitat.

The walleye in the Milwaukee estuary showed a somewhat meandering movement going back and forth between upstream and the harbor within a short period of time. The distance from the outer harbor to the upstream most site where the tagged fish were located was only about 4 km. Some of the tagged fish showed a cruising speed of 0.5 km per hour which would enable them to move between upstream sites and the harbor area within the same day. In our previous study using radio telemetry (Hirethota and Burzynski 2007) 63% of the harbor released radio tagged walleye were detected upstream on the Milwaukee River and 41% of the upstream released walleye were detected in the harbor area.

Movement study using sonic tagging in the Lake Winnebago system in Wisconsin (Ryan Koenigs, Fish Bioloigst, WDNR – personal communication) revealed walleye moving throughout the system for spawning and overwintering. The walleye tagged in the upper Fox River showed poor river fidelity during spring spawning runs as they moved to Lake Puckaway for spawning. They also observed walleye straying within the Lake Winnebago river system for spawning in other years. Males spent more time in the spawning area providing more spring fishing opportunity than females, as females arrived late in the season and left soon after spawning (Koenigs 2013).

We had only one female walleye transmitting for more than two years (walleye 623). This fish travelled upstream in each spring since it was intially tagged and released in the harbor in spring of 2010. It went upstream as early as February 29 of 2012 and probably remained in the area all March because it was detected in the inner harbor on April 10, 2012. Flow conditions varied from year to year in the Milwaukee River (Figures 17-19). A sudden increase in the flows in early March (Figure 19) may have attracted this walleye to move upstream in early spring of 2012. Though another walleye (walleye 625; male) continued to transmit until May 26, 2012, it was not detected in the spring moving up the Milwaukee River during this high flow period. It seems to have resided in the harbor area through the 2012 winter and beyond. The walleye movement study in the Lake Winnebago system also showed that male and female showed different movement patterns. Also, spring discharge rates and timing in the Milwaukee River varied from year to year which may have an impact on walleye spring spawning runs. A sudden influx of freshwater due to storm events may be triggering fish movement in the lower reaches of the Milwaukee River. Jennings et al. (1996), in their study on heritable characteristics, demonstrated that walleye have genetically based response to environmental cues to move towards spawning habitat.

Our spring spawning assessment in the lower Milwaukee River and harbor also documented walleye initially congregating near the spawning reef below the former North Avenue Dam. The survey results showed very few to none adult walleye in the inner harbor while many were collected near the spawning reef or further upstream. Fin clips and Floy-tag marking of walleye during the spawning assessment documented their movement further upstream of the spawning reef. In our annual spawning assessment conducted from late March to early April from 2010 to 2012, we collected a greater number of ripe male walleye compared to females. Although water temperature was greater than 50^0 F, most female were still green suggesting a possible extended spawning period.

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