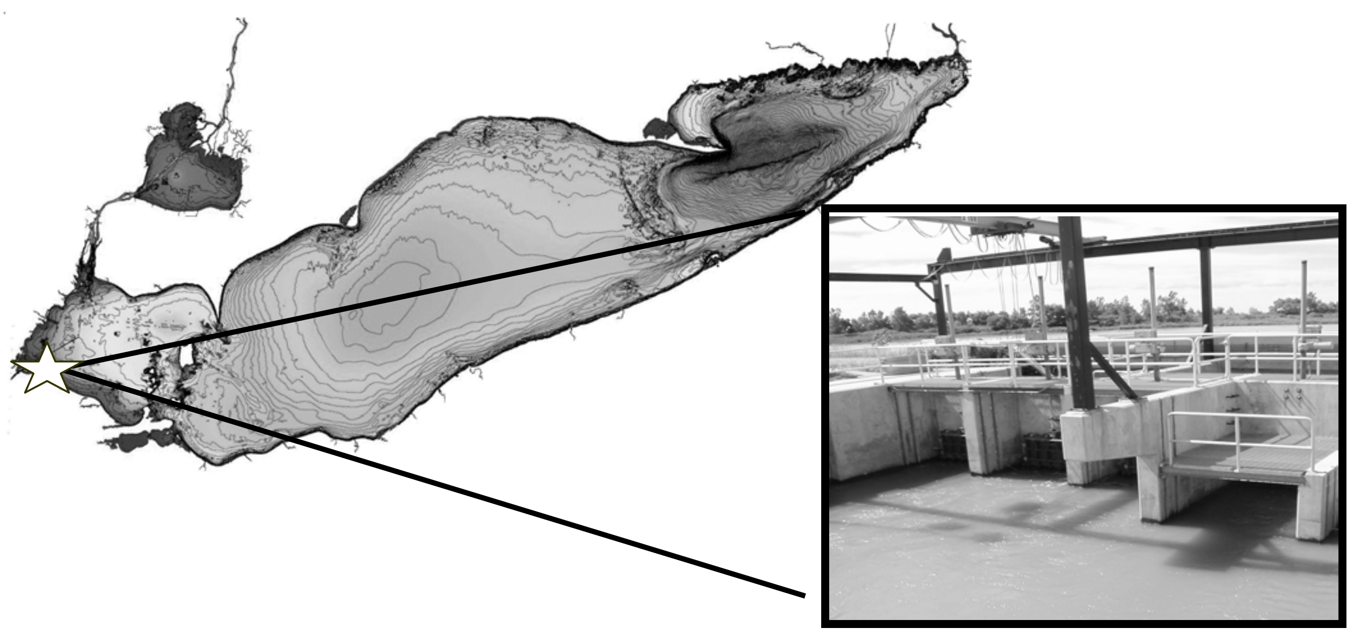
FISH PASSAGE BETWEEN LAKE ERIE AND METZGER MARSH

MONITORING OF AN EXPERIMENTAL FISH PASSAGE STRUCTURE

1999 - 2002
Final Report

December 11, 2002



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Abstract *Metzger Marsh is a 367 hectare (906 acres) coastal wetland jointly managed by US Fish and Wildlife Service (Service) and the Ohio Department of Natural Resources Division of Wildlife (ODOW). In 1995, construction of a 2,348 meter (7,700 feet) dike designed to mimic the eroded barrier beach, completed the Metzger Marsh Wetland Restoration Project. In order to prevent further isolation of wetlands to Lake Erie fish communities, a fish passage structure was integrated into the design. The structure includes trapping apparatuses in front of two of the five water control gates (screw gates), designed for sampling fish movement into and out of the marsh. The Army Corps of Engineers permit requires that the five screw gates be open for a minimum of four years to evaluate marsh and fish community response. Conceptually, this will allow the system to interact with Lake Erie on a hydrological and biological basis. The gates were opened in March of 1999 and fish monitoring began in the April of 1999. Fish community monitoring at the structure and within the marsh has revealed the importance of this system to Lake Erie fishes, both seasonally and for the resident community. Preliminary data suggest that the marsh is of great importance as a nursery area for several key species. As of November 2002, 45 species of fish from 16 families were identified in fish sampled at the Metzger Marsh fish structure. The fishery data will be important to agency managers for future operation and management planning purposes.*

Introduction

The Great Lakes coastal wetlands are sources of high productivity. They provide reproductive, rearing, and protective habitats for numerous animal species along with nutrient exchange with the lakes. The Great Lakes have suffered substantial loss of their coastal wetlands over the past century. Agriculture and development have claimed an estimated 60 to 80% of the original wetlands (Comer et al. 1995). The shoreline of Lake Erie has been developing at a faster rate than any other part of the Great Lakes (Bookhout et al. 1989). Approximately 90% of Ohio's original coastal marshes have been lost to development and agricultural activities (Dahl and Johnson 1991; Herdendorf 1987).

Of the remaining coastal wetlands along western Lake Erie, approximately 84% are disconnected from the lake because of diking activities used to promote agriculture, development, and single-use habitat production. This has resulted in a decline of water quality and aquatic species diversity (Steedman and Regier 1987). Lacking a connection, the coastal wetlands and nearshore habitats of western Lake Erie no longer function as a single ecosystem. It has been speculated that the diversity of aquatic species utilizing coastal wetlands is related to high levels of primary productivity associated with the marshes (Stephenson 1990). This species diversity is maintained within a coastal wetland by rejuvenation from the fluctuations of Great Lakes water levels (Geis 1979). Coastal wetlands are buffer zones which normally trap sediment and moderate flood events. Without coastal wetlands, Lake Erie is vulnerable to degradation from pollution and lack of enrichment because runoff from surrounding lands is no longer filtered through these wetlands (Mitsch and Bouchard 1998).

Fishery management within diked systems has been given little consideration. Fish communities utilize coastal wetland systems for spawning, nursery, feeding and protective areas. Fish diversity within a freshwater coastal marsh can be quite extensive. Almost all freshwater fish species use wetland areas at some point in their life cycle (Mitsch and Gosselink 1993). It has been estimated that 47 species of Lake Erie fish are, or have been, associated with the coastal wetlands during some stage of their life cycle (Johnson 1989). Decline in fish abundance since 1850 has been attributed to inaccessibility, due to diking and draining, of coastal wetlands (Trautman 1981).

The Ohio Division Of Wildlife (ODOW), United States Fish and Wildlife Service (Service), and Ducks Unlimited initiated a joint wetland restoration project for Metzger Marsh in 1992. The purpose of the project was to restore 367 hectares of lucastruine / palustrine habitat by building a 2,348 meter dike to mimic the eroded barrier beach. From the 1930's until the mid 1940's the marsh was owned and operated as an onion farm. During that period, a barrier beach existed in front of the marsh. This beach acted as a buffer, protecting the farm from wave energy and other erosion forces. In the early 1960's lake levels began to rise. Water levels continued to rise and maintained their high levels for three decades. The resulting wave energy finally caused the barrier beach to erode away during a storm event in 1972 leaving the marsh open to unimpeded wave action. In an effort to maintain connectivity with Lake Erie, an experimental structure was proposed for Metzger Marsh. The newly renovated dike would maintain an opening to the lake allowing for nutrient exchange and species migration between the two systems by incorporating a fish passage and water control structure into the design. The purpose for this experimental structure was to explore other methods of marsh management that would embrace an ecosystem approach and optimize species diversity while providing protection from large storm events. This structure was added to the dike in 1996 and began operating in the spring of 1999. A U.S. Army Corps of Engineers (Corps) permit allowed the construction and contained requirements to evaluate the ecological effectiveness of the restored system. The permit also states that after re-vegetation of the marsh, the five water control gates and screw gates at Metzger Marsh are to remain open for a minimum of four years. This would allow the marsh water levels to fluctuate "naturally" with lake levels. During this time, the fish trapping facility was to remain in operation to monitor the migration of fish in and out of the marsh while excluding carp by means of the grating system. One of the components of the permit was a requirement to evaluate and compare the pre- and post-construction flora and fauna utilizing the marsh. Critical to future management of the marsh was a need to determine the temporal use of the marsh by Lake Erie fish species. This report provides a summary of findings relative to monitoring of the fish community utilizing the restored (post-construction) marsh.

Study Site

Metzger Marsh is a 367 hectare coastal wetland on Lake Erie. It is approximately 32 kilometers east of Toledo, Ohio. A 2,348 meter lakefront dike was built in Metzger Marsh with an experimental fish passage structure to promote species diversity and maintain a connection with Lake Erie.

Fish access was incorporated into the design of the dike to enhance the ecosystem benefits of the restoration project. The fish passage structure is 12.2 meters wide with five openings. Each opening is 1.5 m x 1.5 m with mechanically operated screw gates. The fish passage structure contains two trap baskets. One of the traps is set to sample fish entering the marsh (ingress) while the second trap is set to sample fish leaving the marsh (egress). These traps are set in the east and west openings respectively. The baskets allow a portion of the fish moving between the lake and the marsh to be examined.

The original trap design utilized in 1999 and 2000 was not effective in sampling the entire water column. While the water depth at the structure averaged 1.5 – 1.8 m, the traps were only 0.9 m in height. Once the fish entered the trap, they were free to swim out because the top was completely open. The traps were redesigned in 2000 to more efficiently sample the entire water column. The redesigned traps are 2.4 m in height and are constructed of galvanized steel with a tunnel in the front containing "fingers" which allow fish to enter but not exit (Figure 1). It is comprised of a grating system on all sides which are 5 x 30 cm. A 5-ton overhead crane is used to maneuver the baskets. A series of removable grates can be placed in front of all five openings. There are various grate sizes, ranging from 5 to 20 cm, which will be used to determine the best grate size for prohibiting entry of carp but allowing desirable fish species to pass freely.

Figure 1. Fish trapping baskets were re-designed in 2000 to more effectively sample fish entering Metzger Marsh. Photo on left shows the grate system used to limit access by larger fish and the crane used to lift the basket from the water. Photo on right shows the entrance to the basket guarded by "fingers" to prevent escape once fish have entered the trap.

Methods

The information in this report represents data from 1999 through 2002. All data is analyzed using CPUE (catch per unit effort). This was determined by dividing the number of individuals captured by the number of days sampled. In August of 2000, the sampling traps were replaced with a new design. Prior to this modification, the traps used to collect data were inefficient in capturing fish entering and leaving the marsh. Although a primary objective of the monitoring program was to determine timing of fish migration, attempts to draw conclusions relative to comparisons between fish ingress and egress are greatly confounded by the size of the grating used to construct the traps. The 5 cm gap in the grates allows small fish to enter and exit from either side of the basket and does not allow for determination of direction of travel. Due to this data bias, the ingress and egress data were combined for a majority of this report and simply represents the catch "at the structure".

Sampling of the fish passage structure began in 1999 and continued through November 2002. The baskets were lifted twice daily during spring months, reduced to daily lifts during the summer, and as fish migration diminished in the fall, baskets were lifted once daily, twice weekly.

Fish captured in the baskets were identified to species; counted, weighed (g), and measured (total length in millimeters). All sport fish were tagged with t-bar anchor tags and the right pectoral fin was clipped to determine movement patterns relative to entry, exit, and re-entry on a temporal basis. Fin clipping was used on fish over 100 mm in length. Scale samples were also removed from sport fish for age determination.

Abiotic parameters were recorded for every lift and set of the trap baskets. Dissolved oxygen, pH, conductivity, bottom water temperature, surface water temperature, air temperature, wind direction and speed, water depth, flow direction, and transparency were recorded. These same parameters were also collected during larval sampling at the structure.

Larval sampling was conducted, weekly in 2000 and monthly in 2001, during the evening hours beginning in mid-April. Four ten-minute samples were collected using a 0.5 m ichthyoplankton net (303μ) which was positioned on the downstream side of the fish trapping area (dependent on the flow direction at the time of sampling). Larval sampling concluded in August. Samples were preserved in 10% ethanol for later identification. Analysis of those samples has not occurred and is not discussed in this report. Results of that study will aid in determination of larval fish production and use of the wetland.

Results

In 410 days of sampling during 1999 - 2002, a total of 45 species of fish were identified at the fish passage structure (Table 1). Species sampled at the Metzger Marsh fish passage structure were categorized into three guilds that are most relevant from a marsh management perspective. These categories were phytophilic, lake, and tolerant species. Tolerant species consist of individuals which are resilient to harsh environmental conditions such as low oxygen levels.. Examination of these guilds can be compared with data collected inside the marsh, allowing for a more accurate analysis of the direct benefits of coastal marsh restoration efforts to species that rely on these critical habitats.

Table 1. Combined total catch of fish sampled at the Metzger Marsh fish passage structure from 1999 -2002. Catch Per Unit Effort (CPUE) is the total number of individuals captured per day. Catches of the three most abundant species of each guild classifications are bolded: ^{T} indicates tolerant species, ^{L} indicates open lake species, and ^{P} indicates phytophilic species (per Johnson and Braig 2002).

Common Name	Scientific Name	Total Catch From 1999 - 2002	
		number	*CPUE*
Emerald Shiner	***Notropis atherinoides***^{L}	**37735**	**92**
Spottail Shiner	***Notropis hudsonius***^{L}	**4286**	**10**
White Perch	***Morone americana***^{L}	**2630**	**6**
Alewife	*Alosa pseudoharengus*^{L}	2258	6
White Bass	*Morone chrysops*^{L}	1238	3
Freshwater Drum	*Aplodinotus grunniens*^{L}	286	< 1
Mimic Shiner	*Notropis volucellus*^{L}	1	< 1
Quillback	*Carpiodes cyprinus*^{L}	252	< 1
Rainbow Trout	*Oncorhynchus mykiss*^{L}	10	< 1
Smallmouth Bass	*Micropterus dolomieu*^{L}	33	< 1
Rainbow Smelt	*Osmerus mordax*^{L}	8	< 1
Troutperch	*Percopsis omiscomaycus*^{L}	26	< 1
Walleye	*Stizostedion vitreum*^{L}	133	< 1
Yellow Perch	*Perca flavescens*^{L}	78	< 1
Gizzard Shad	***Dorosoma cepedianum***^{T}	**59270**	**145**
Goldfish	***Carassius auratus***^{T}	**1395**	**3**
Carp	***Cyprinus carpio***^{T}	**627**	**2**
Bigmouth Buffalo	*Ictiobus cyprinellus*^{T}	21	< 1
Bluntnose Minnow	*Pimephales notatus*^{T}	134	< 1
Channel Catfish	*Ictalurus punctatus*^{T}	42	< 1
Green Sunfish	*Lepomis cynanellus*^{T}	3	< 1
Orangespotted Sunfish	*Lepomis humilis*^{T}	51	< 1
Spotfin Shiner	*Cyprinella spiloptera*^{T}	87	< 1
White Crappie	*Pomoxis annularis*^{T}	97	< 1
White Sucker	*Catostomus commersoni*^{T}	70	< 1
Largemouth Bass	***Micropterus salmoides***^{P}	**2803**	**7**
Sand Shiner	***Notropis stramineus***^{P}	**986**	**2**
Bowfin	***Amia calva***^{P}	**909**	**2**
Pumpkinseed	*Lepomis gibbosus*^{P}	434	1
Black Crappie	*Pomoxis nigromaculatus*^{P}	52	< 1
Bluegill	*Lepomis macrochirus*^{P}	372	< 1
Brown Bullhead	*Ameiurus nebulosus*^{P}	15	< 1
Golden Shiner	*Notemigonus crysoleucas*^{P}	68	< 1
Longnose Gar	*Lepisosteus osseus*^{P}	18	< 1
Northern Logperch	*Percina caprodes semifascita*^{P}	53	< 1
Northern Pike	*Esox lucius*^{P}	14	< 1
Rockbass	*Amploplites rupestris*^{P}	72	< 1
Tadpole Madtom	*Noturus gyrinus*^{P}	11	< 1
Yellow Bullhead	*Ameiurus natalis*^{P}	35	< 1
Round Goby	*Neogobius melanostomus*	2108	5
Creek Chub	*Semotilus artomaculatus*	1	< 1
Silver Redhorse	*Moxostoma anisurum*	1	< 1
Silver Chub	*Macrohybosis storeriana*	1	< 1
Sea Lamprey	*Petromyzon marinus*	3	< 1
Shorthead Redhorse	*Moxostoma macrolepidotum*	2	< 1

An examination of total CPUE on a temporal basis illustrates that catch was greatest during July and August (Figure 2). Fish less than 250 mm in length comprised 88% of the total CPUE in

July and August. Based on observation and earlier research (French et al., 1999), fish larger than 250 mm have difficulty moving through the grates especially when confronted with water flow through the structure.   Sub adult gizzard shad were the dominate species during August. It is during the months of July and August when juvenile and young of the year began to appear (Figure 3).

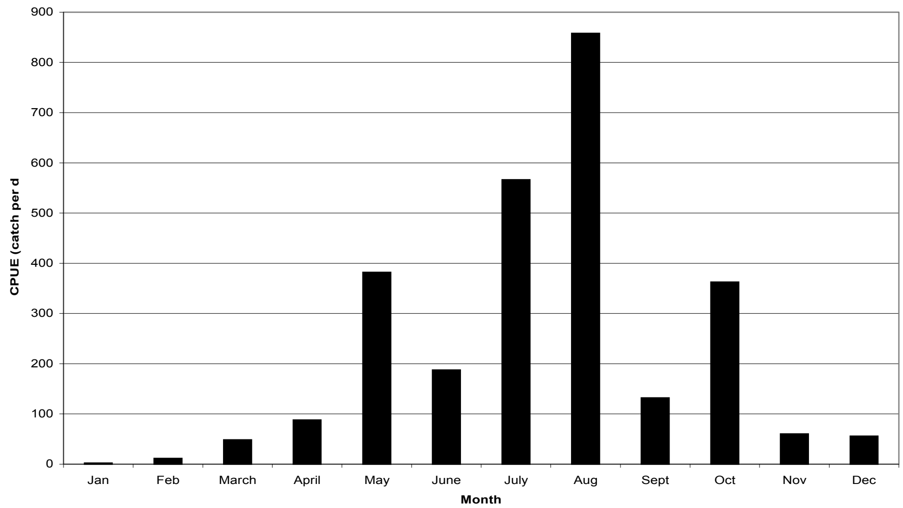

Figure2. Mean monthly CPUE, all species, ingress and egress combined, for fish sampled at the Metzger Marsh fish passage structure, 1999-2002.

Examination of the catch based on life stage (size) illustrates the importance of the marsh as a nursery area. Figure 3 displays mean monthly length frequency distribution of gizzard shad, which, by number, was the most abundant species sampled at the fish structure. A majority of the gizzard shad captured were captured in July and August as young-of-the-year (YOY) fish. Gizzard shad are an important forage species for Lake Erie predators such as walleye.

Largemouth bass were captured from February through November; however, the catch was dominated by YOY captured in July-August (Figure 4). In both Figure 3 and Figure 4, although some adult and sub-adult fish were present in the March-June catch, there is nothing to imply or confirm that the recruitment indicated by the abundance of YOY fish came from within the marsh. As previously discussed, the grates in front of the sampling baskets would allow free movement of small fish in and out of the basket. It is, however, probable that the resident population of largemouth bass that has become established in the marsh is reproducing and is likely the source of recruitment for that species.

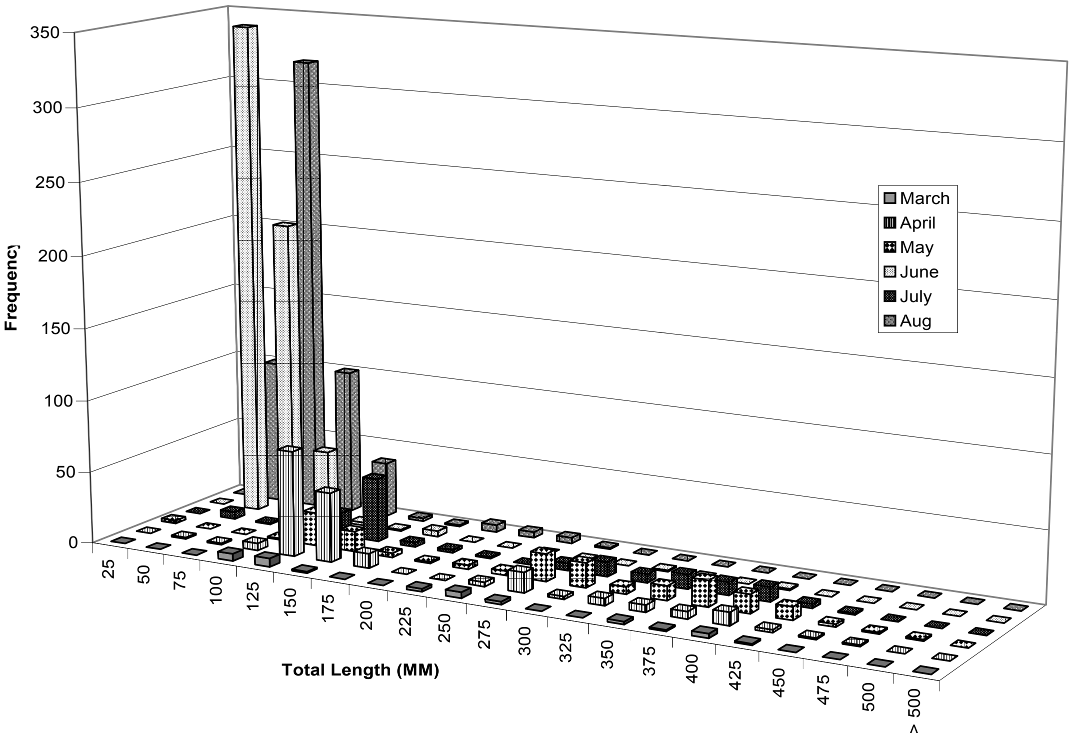

Figure 3. Length-frequency distribution of gizzard shad, ingress and egress combined, by month of sample at the Metzger Marsh fish passage structure, 1999 - 2002.

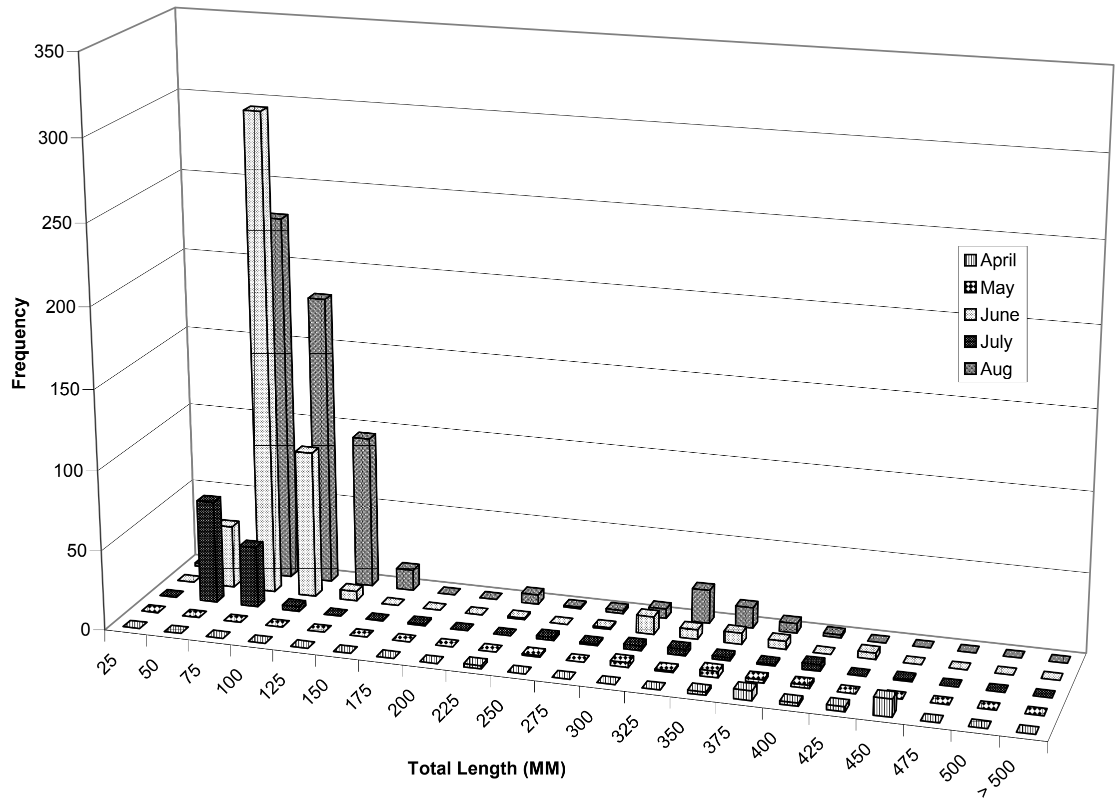

Figure 4. Length-frequency distribution of largemouth bass, ingress and egress combined, by month of sample at the Metzger Marsh fish passage structure, 1999 - 2002.

As with the gizzard shad and largemouth bass, white bass YOY were captured during July and August (Figure 5). In the case of white bass, however, there is an indication that the adult fish captured in the May sampling may be producing the recruitment observed in the July and August samples. Ripe running male and female white bass were observed during the sampling in May.

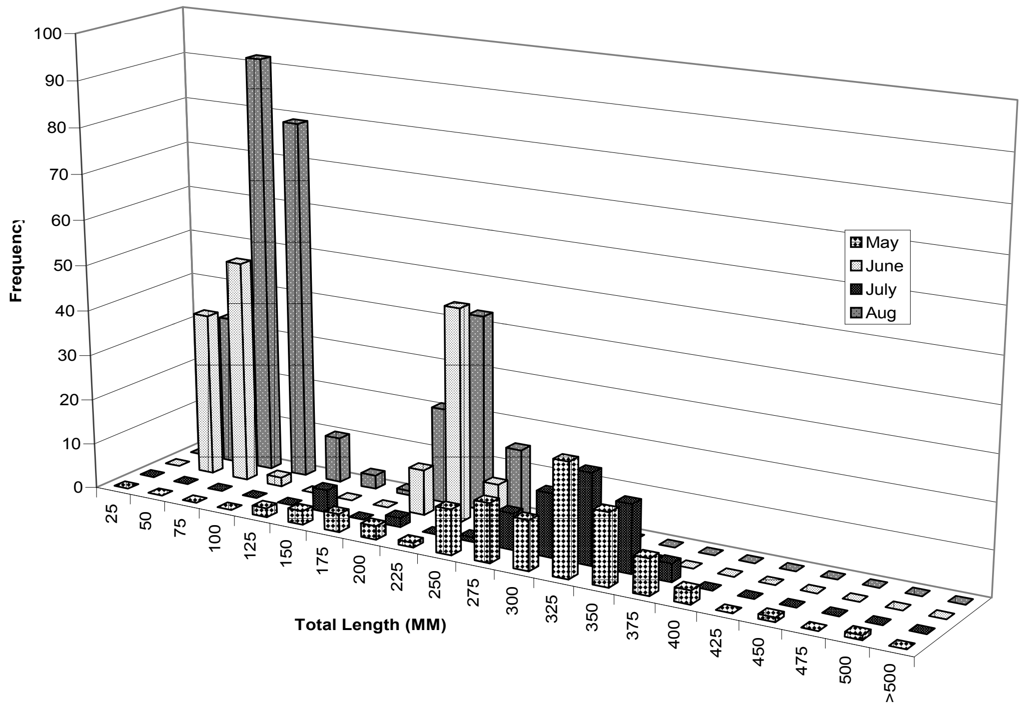

Figure 5. Length-frequency distribution of white bass, ingress and egress combined, by month of sample at the Metzger Marsh fish passage structure, 1999 - 2002.

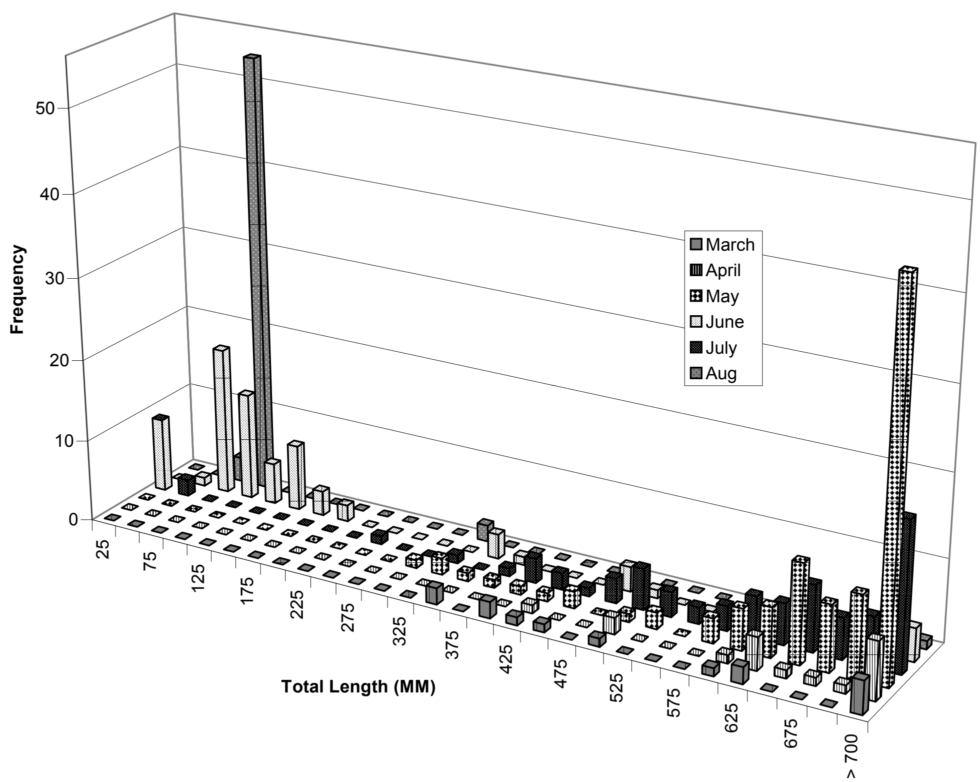

Figure 6. Length-frequency distribution of carp, ingress and egress combined, by month of sample at the Metzger Marsh fish passage structure, 1999 - 2002.

Examination of carp length-frequency distribution data shows that although carp greater than 340 mm begin to appear in the catch in March they were most abundant in May and June (Figure 6). It is during this time when ripe males and females were observed in the traps. Carp recruitment is occurring in or near the marsh as YOY specimens are showing up in the catch in July and August (Figure 6). A more detailed examination of the temporal aspects of carp movement will be required to determine if the May and June period is associated with spawning ingress and will be necessary to develop a management strategy to include exclusion of carp from the marsh. A resident carp population does exist in the marsh and confounds this preliminary evaluation

In August of 2000, the new trap design was used to sample fish movement through the structure. The trapping efficiency of adult fish increased allowing examination of fish movement between Lake Erie and Metzger marsh on a temporal basis. Fish larger than 250 mm sampled at the structure were separated from the catch and examined by direction of movement (Figure 7). Based on observation and earlier research (Wilcox et. al., 1999), fish of this size and larger have difficulty moving through the grates especially when confronted with water flow through the structure.

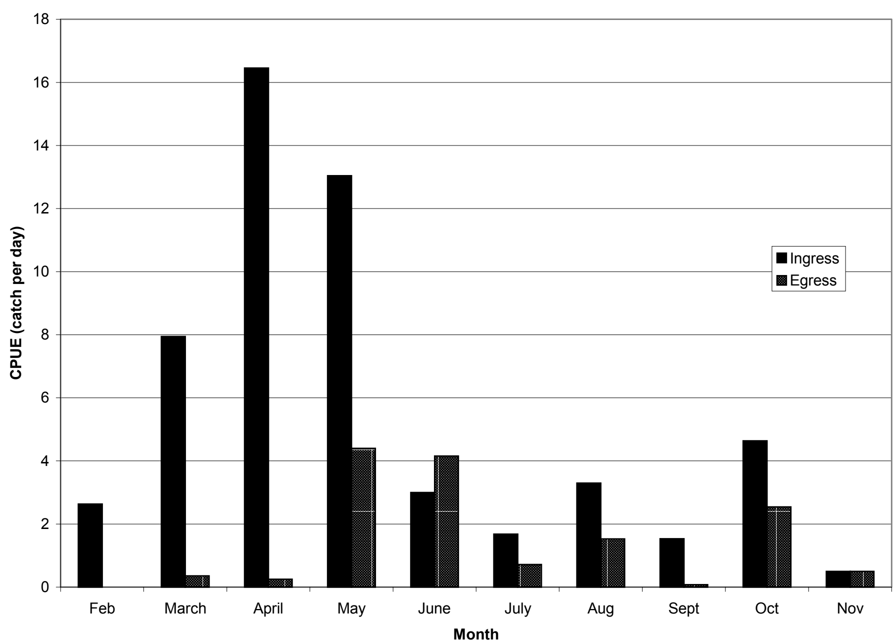

Figure 7. Mean monthly directional CPUE, all species greater than 250 mm in length, for fish sampled at the Metzger Marsh fish passage structure, 2001-2002.

In general, ingress of fish in this size category is highest from March – May. An observable decrease in adult movement occurred through the summer and fall. Adult walleye show a definite migration pattern in the spring and fall (Figure 8). Some ripe males have been observed during the spring movement.

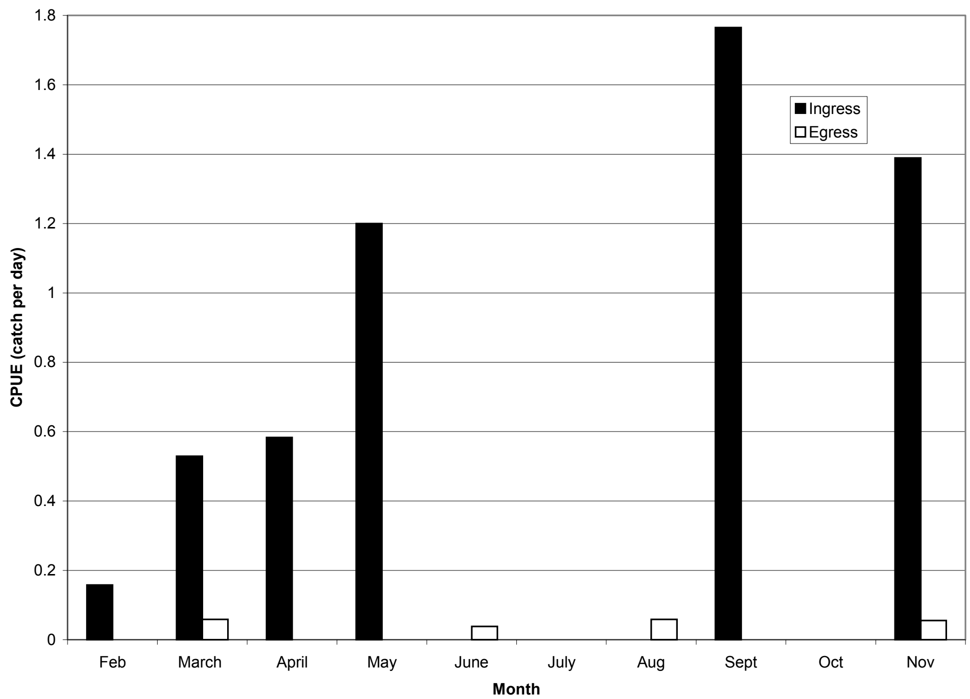

Figure 8. Mean monthly directional CPUE of walleye, greater than 250 mm in length, sampled at the Metzger Marsh fish passage structure, 2001-2002.

Bowfin display a migration pattern similar to walleye. Adults were sampled moving into the marsh during the spring, particularly in April, (Figure 9) with outward migration in May and June. There is another small increased movement in the August - October period. Similarly, white bass utilize spring for their ingress migration (Figure 10) with peak movement in May. Unlike walleye, white bass do display an egress migration very shortly after their arrival. The fish are moving into the marsh during May and June and leaving in May and June. The majority of the fish sampled in May and June were observed in their adult stage and in ripe spawning condition. The appearance of YOY white bass and gizzard shad in July and August suggest that the adults captured in spring may be producing the recruitment observed in late summer.

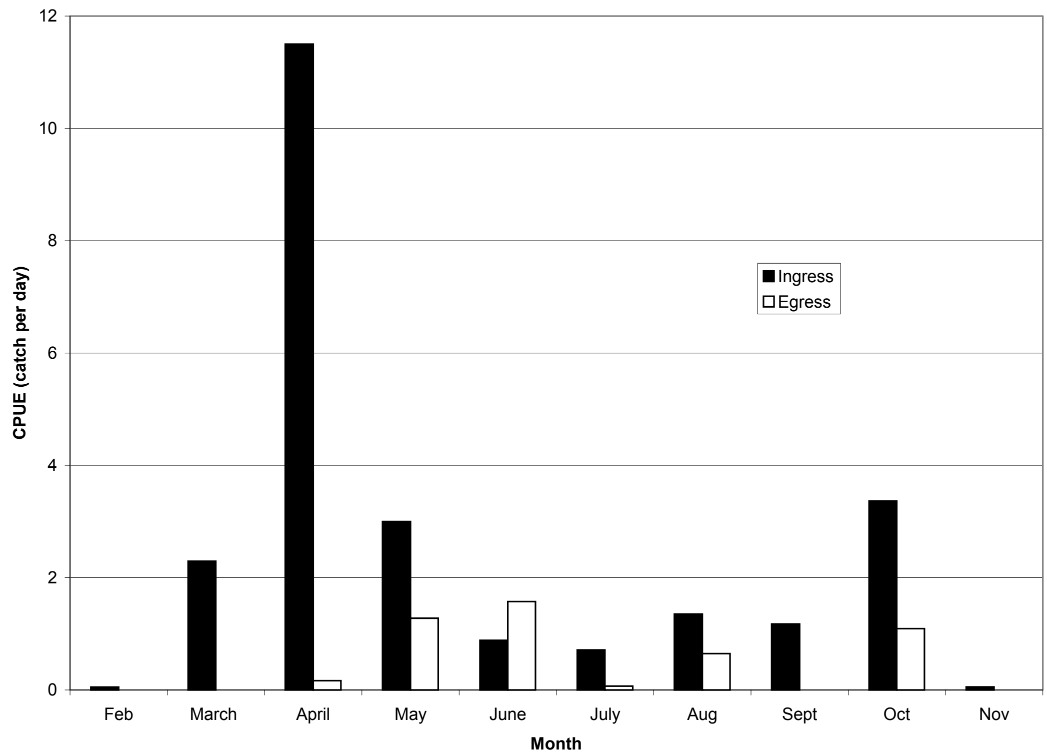

Figure 9. Mean monthly directional CPUE of bowfin, greater than 250 mm in length, sampled at the Metzger Marsh fish passage structure, 2001-2002.

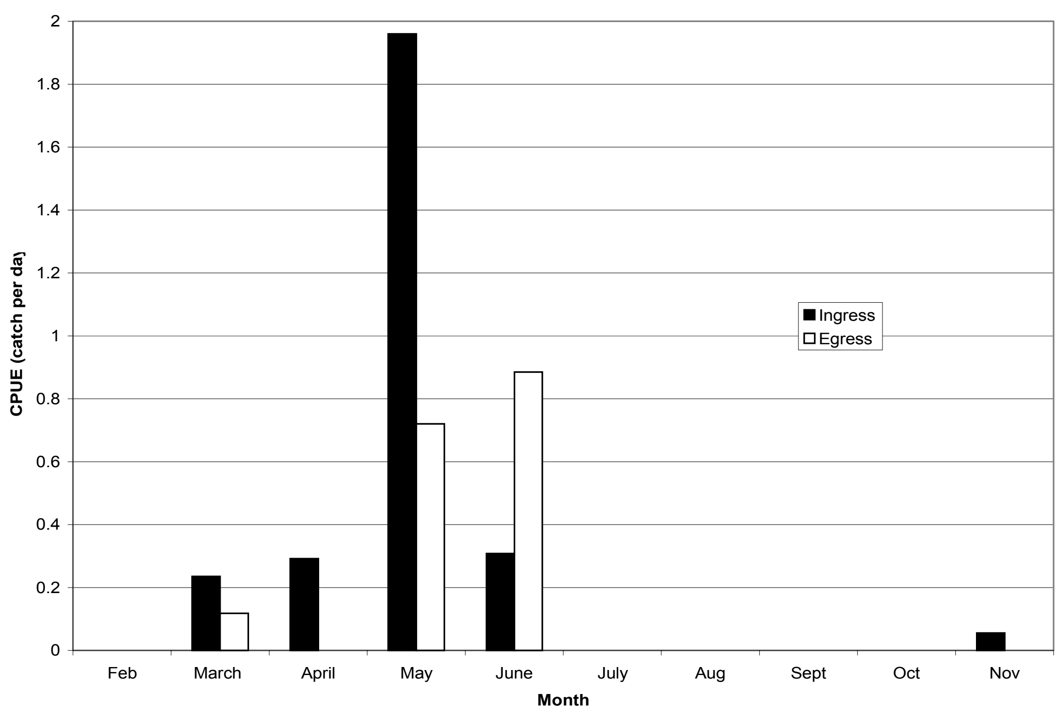

Figure10. Mean monthly directional CPUE of white bass, greater than 250 mm in length, sampled at the Metzger Marsh fish passage structure, 2001-2002.

Two species of interest to marsh managers are carp and largemouth bass. Largemouth bass are desired for recreational opportunities and carp are undesired due to their potential to degrade aquatic habitat. Figure 11 illustrates movement trends of largemouth bass. Largemouth bass greater than 250 mm are captured throughout the year. There does not seem to be a distinct movement pattern and could be indicative of routine movement of a resident population within the marsh.

Similar to the largemouth bass, carp appear throughout most of the year (Figure 12). Capture of carp on the ingress side of the structure occurs March through August. However, ripe individuals were observed in May and June. After the capture of ingress carp, they are returned back into the lake and not allowed to pass into the marsh. Therefore, carp in the egress trap is representative of the resident population.

Northern pike is another species of interest to researchers and managers. They are a species in decline. One goal of this restoration effort was to aid in the recovery of wetland dependent species such as the northern pike. The total CPUE of pike is less than 1 (Table 1). However, in 2002, there has been an increase in the number captured in the ingress traps. It is possible adult pike that are migrating through the structure when the carp exclusion grates have been removed for ice. This would allow the fish to move freely through the structure without having to go through the traps. There has also been YOY and juvenile northern pike sampled within the marsh. This provides evidence that recruitment might be taking place within the marsh.

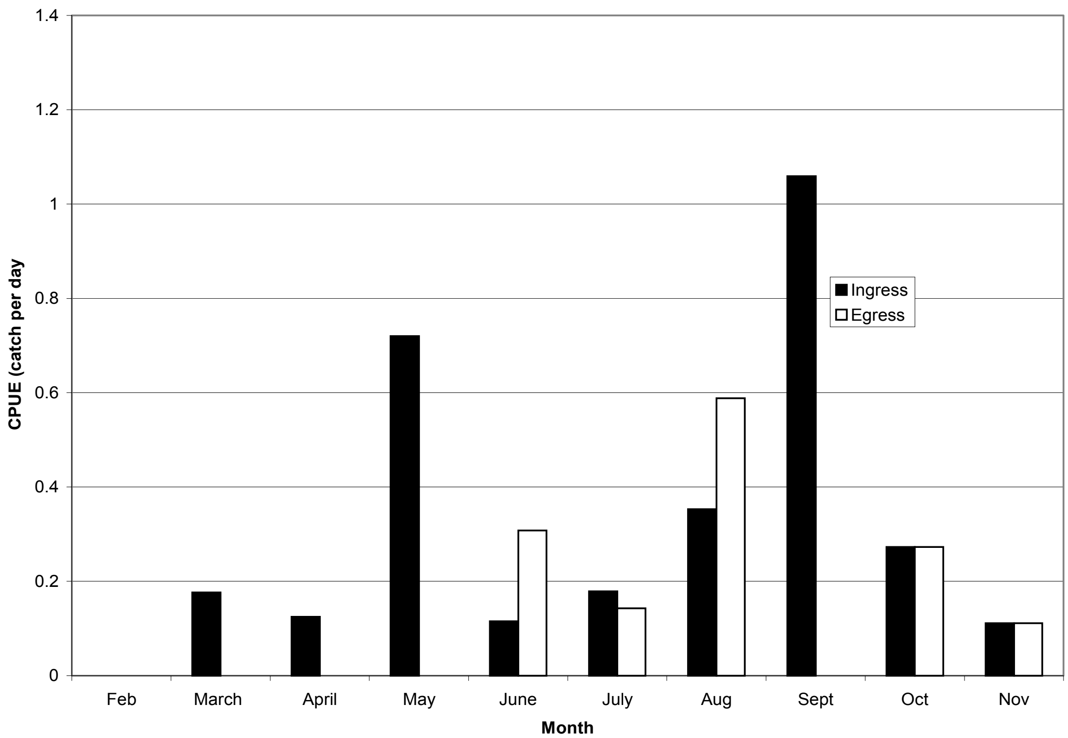

Figure 11. Mean monthly directional CPUE of largemouth bass, greater than 250 mm in length, sampled at the Metzger Marsh fish passage structure, 2001-2002.

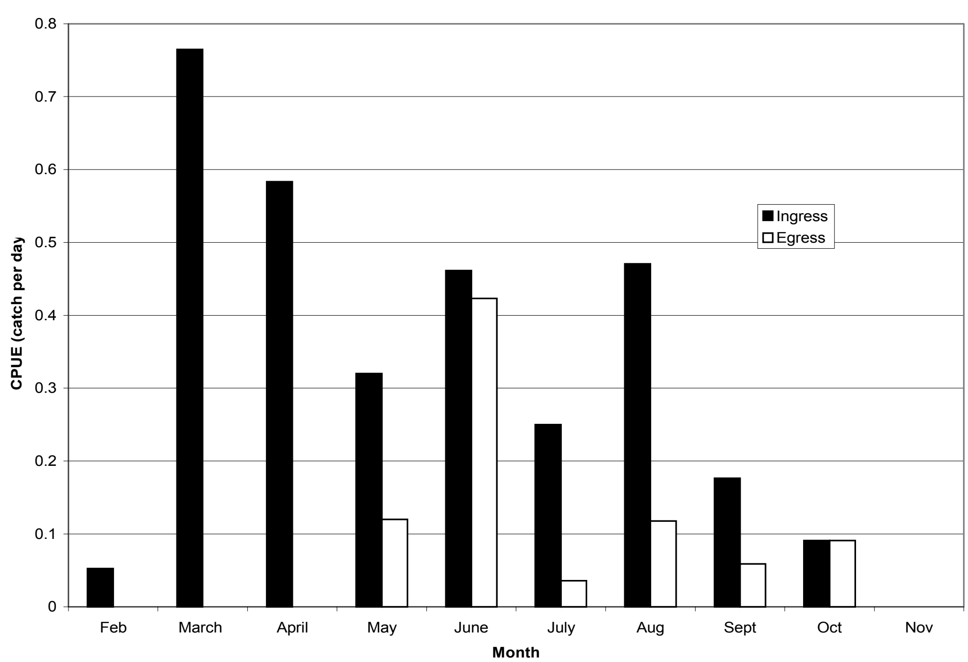

Figure 12. Mean monthly directional CPUE of carp, greater than 250 mm in length, sampled at the Metzger Marsh fish passage structure, 2001-2002.

Four years of collecting data at the structure has shown a steady increase in overall CPUE (Figure 13). At the same time, total carp CPUE has been decreasing. Carp consisted of less than 0.5% of the total CPUE from 1999 – 2002. The extensive carp die off in 2000 might be a contributing factor.

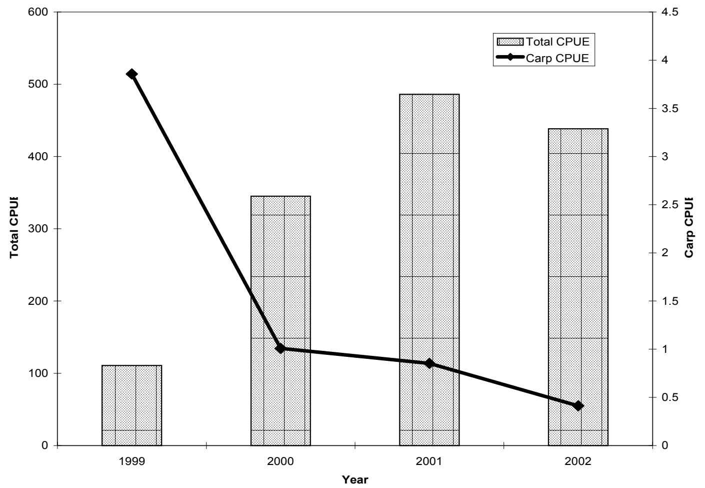

Figure 13. Total annual CPUE for carp, compared with total annual CPUE for other fish species as sampled at the Metzger Marsh fish access structure in 1999-2002. Samples from the ingress and egress baskets are combined.

Discussion

Assessment of the fish community response to the Metzger Marsh Wetland Restoration Project will continue to be an ongoing project. Analysis of fish migration trends requires years of sampling. The results discussed in this report represent data from 1999 through November 2002. The trapping mechanism was ineffective at capturing the movement of fish through the structure during 1999-2000 and prevents definitive information on direction of movement. In fall of 2000 new traps were installed thereby allowing the 2001 and 2002 data to be analyzed for migration patterns of adult fish

Based on the evaluation of data collected at the structure in 2001-2002 , catch of fish >250 mm was greatest during the months of April, May and June. Species captured in April and May on the ingress side of the structure include gizzard shad, walleye, white bass, bowfin and quillback. Some of these individuals were in spawning condition. The majority of larger fish (>250 mm) captured on the egress side of the structure were encountered in May and June. Subsequent years of data collection are needed to describe these trends with more confidence.

Juvenile and YOY fish dominated the catch during the four years. July and August had the highest rate of catch (combined ingress and egress from 1999 – 2002) with juvenile and YOY fish dominating the catch. These months are important for age 0 fish, less than 50 mm in total length. Gizzard shad, white bass, and largemouth bass, display trends of spring adult migration with the appearance of young fish in the summer. This information provides evidence that the marsh is being utilized as a nursery area. Testing of this hypothesis will need to be done in conjunction with data collected from inside of the marsh. It is possible that the young fish sampled at the structure could be from the lake. We have not been able to determine whether any of the recruitment is occurring within the marsh, but the capture of sexually mature adult white bass, white perch, largemouth bass, and gizzard shad, followed by the appearance of YOY in July indicates the likelihood of spawning occurring in or near the marsh. The capture of adult northern pike at the structure and YOY pike in traps within the marsh indicate the potential for this marsh system to aid in recovery of this depleted native species (Figure 14).

Species such as gizzard shad, alewife, and emerald shiners are important forage food for walleye and other large predators. Their presence, in the marsh and at the structure, suggests a contribution to the health of the Lake Erie fishery for Metzger Marsh (Figure 14).

Figure 14. Restoration of the Metzger Marsh coastal wetland has shown to be beneficial to the Lake Erie fish community as a nursery area to several species of fish, including important forage species such as gizzard shad (L) and may aid in recovery of depleted native species such as northern pike (R).

Determining the timing of carp migration into and out of Metzger Marsh was a major objective of the study and would be critical to development of marsh management strategies. Carp consisted of less than 0.5% of the total CPUE for ingress and egress samples from 1999 - 2002. Since the opening of the marsh in 1999, the catch rate of carp has decreased. For management purposes, carp movement was examined on a temporal basis. The majority of adult carp were coming into the marsh in February and March. However, ripe males and females were observed during the month of May. Movement of carp out of the marsh was predominantly during June. Carp are not allowed access into the wetland when they are sampled in the ingress trap. Therefore the fish leaving the marsh in June are part of the resident carp population.

In order to confidently assess temporal movement of fish through the structure, continued open marsh monitoring is needed. There are many factors that affect the movement of fish. In the two years of sampling with effective traps, trends are beginning to develop. However, this does not constitute an extensive enough sampling for mangers to clearly define movement patterns.

Effective long-term management of this coastal marsh to optimize benefits to all fish and wildlife resources will require an adaptive management strategy based on continued monitoring and periodic adjustment to structure operation. With increased pressure on water resources and lack of habitat for a multitude of wetland dependent species, it is essential that managers examine restoration alternatives that encompass an ecosystem approach.

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Recommendation

Traditional impounded wetland management at the Ottawa National Wildlife Refuge consists of periodic draw-downs to encourage growth of desirable vegetation while inhibiting exotic and invasive vegetation. A typical draw-down (water removed to expose mudflats) occurs in the spring with reflooding in early fall. The fishery data was examined using target dates of mid-May for drawdown and mid-August for reflooding as recommended by refuge staff.

It is our opinion that a draw-down covering the mid-May through mid-August period could not occur without a detrimental impact to the fish utilizing the system. Based upon the fishery data collected at the structure, a drawdown during this time period and for this duration could not avoid an interruption to recruitment. In addition, fish entering the marsh in the spring would be subject to stranding when the water is lowered. Similarly, stranding would be a concern for resident fish populations such as largemouth bass.

A preferable option during a drawdown year would be to prevent entry of fish into the marsh by placing stop-logs or closing the gates as soon as ice-out has occurred. To minimize costs associated with pumping, and the physical damage pumping may cause to fish, managers might consider using natural seiche events to remove much of the water. When the wind is blowing from the west, southwest, and south the water is flowing out of the marsh. During these times the gates and stop-logs can be opened to allow the water to flow out and thereby allowing fish to migrate out of the marsh. Once the event is over the gates can be closed until the next seiche. Periodic recruitment failure is not unusual in the Great Lakes, due to climatic conditions. Loss of recruitment in years when water level manipulation is required for control of exotic vegetation, especially when weighed against benefits to improved habitat quality is acceptable. However, draw-downs should not occur more frequently than one out of three or four years. Resident fish populations will be stranded in those years and the managing agencies will need to plan for large-scale rescue efforts. This is especially important for sensitive and less mobile species such as the unionids.

It is the overall recommendation, from the fishery prospective, to maintain an open and free flowing system as much as possible.