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Establishment of Historic Fish Communities to Restored Illinois River Floodplain Lakes

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EXECUTIVE SUMMARY

From 2006-2009, efforts were made to establish species of fishes that were native to floodplain backwater lakes of the Illinois River. Past restoration at several sites has focused mainly on the sportfish community and centered around largemouth bass, black crappie, white crappie and bluegill. This project focused on the ability to diversify the native fish species that were reintroduced. A total of 35 species were stocked and totaled 1,711,055 individuals. The goal of establishing four to six species at each of the three study sites was achieved and exceeded at Emiquon, possibly met at Spunky Bottoms but additional monitoring is needed, not met at Hennepin-Hopper as the system collapsed under the weight of the expanding carp population before species could be fully stocked. This project was the largest effort ever to establish native fish communities along the Illinois and required the cooperation of the Illinois Natural History Survey, Illinois Department of Natural Resources, The Nature Conservancy, and The Wetlands Initiative. Additional stocking and monitoring of the lakes are recommended. Studies of other similar lakes are recommended for future establishments of native fish communities.

INTRODUCTION

The floodplain backwater lakes and sloughs of the Illinois River have a long history of change in which these environs have been drained and degraded to the point that the aquatic communities no longer exist (Havera, et. al., 2003, Retzer, et. al., 2009). Although it is highly unlikely that the river or any of the Midwestern rivers can be restored to historical conditions, efforts are being done along the Illinois to re-establish plant and animal communities as functional and sustaining units that will resemble the historic communities. In particular, the Illinois Department of Natural Resources, The Wetlands Initiative, and The Nature Conservancy have been restoring thousands of acres in the Illinois River Valley.

Funding to establish historic fish communities to three sites along the Illinois River was provided to the Illinois Natural History Survey through the State Wildlife Program. The ultimate goal was to reintroduce four to six native floodplain fish species to the Hennepin-Hopper Lakes, Emiquon (Thompson and Flag Lakes), Fulton County, and Spunky Bottoms, Brown County. By reintroduction, we mean that each of the species will be established and reproducing at the site. This goal sets a fairly high standard in that while the stocked individuals may be easily detected early on, showing evidence of spawning could take additional time to detect young-of-the-year. The duration of this project was fall of 2006 to the fall of 2009 and relied upon the cooperation of the Illinois Natural History Survey, Illinois Department of Natural Resources, The Nature Conservancy, and The Wetlands Initiative.

This report details the methodologies used to select the species for stocking, how stock material was obtained, propagated, and stocked. We also report upon the success and failures of the project, much of which was experimental in nature. The report is divided into two sections. The first section described the stocking of each of the lakes and results of the stockings. Included is a general description of the lakes and how the changing conditions of each lake dictated the species stocked and how they were obtained and stocked. We believe that this information will be helpful to future scientists

and managers who wish to restore historic fish communities in large dynamic bottomland lakes. In addition, we reported on monitoring methods (sounds, snorkeling) not normally used in these kinds of systems or on fishes. We then summarize the results and make recommendations for the future.

The second section lists the species stocked and gives information on where the stocking material was obtained. Also we include the associated data that may be useful in increasing the probability of success of stocking these species and how to measure the success of the stockings. This information includes size ranges of the stocked individuals, tolerance to capture and stocking, availability of species in the wild, propagation in ponds, ditches, and enclosures, and special issues (e.g., predators, competitors, special habitat requirements etc.) for biologists and managers to consider.

Methodologies and Results of Stocking Efforts At Hennepin-Hopper, Emiquon, and Spunky Bottoms.

General Discussion

A list of species native to the Illinois River and its associated backwaters was developed based on historical records and studies of the river (Table 1). Illinois is one of the few states that have excellent data on fish distributions. This data extend over 125 years. Information from Forbes and Richardson (1920) was very useful as well as a Master's thesis by Craig (1898) on the fishes of the Illinois River and lakes around Havana area including Emiquon. Input from IDNR fish biologists was also utilized in the development of the list. The list intentionally omitted the most common Centrachidae sportfish that are routinely stocked after rehabilitations (ie. Largemouth bass, bluegill, white and black crappie). These native fish were scheduled to be stocked as key predators on the exotic and invasive fish species that maybe present at the sites. The list concentrated on those species that would have been found primarily in the backwater lake habitats. The list focused on these species because of the extreme rarity of these communities within the Illinois River today. However, the species that could be stocked was not limited to these because many other more common species would have also occurred in these lakes. Most of the species that were stocked came from the list or were those that would have occurred in the lakes. At each lake we attempted to stock species that would have increased diversity of less represented genera or families such as topminnows (Fundulidae) and darters (Percidae), species that would utilize a variety of habitats such as shallow top-water and benthic habitats, and would represent different trophic levels. Still, a few species were stocked because they were easily obtained or because the changing conditions at the sites dictated that another species might be more suitable for stocking. See Appendix 1a-c lists of species stocked, year stocked and the number of individuals stocked for each lake.

Table 1. List of species originally proposed to stocking into Emiquon, Hennepin-Hopper Lakes, and Spunky Bottoms.

Ameiurus nebulosus	(Brown bullhead)
Amia calva	(Bowfin)
Aphredoderus sayanus	(Pirate perch)

Erimyzon sucetta	(Lake chubsucker)
Esox americanus	(Grass pickerel)
Esox lucius	(Northern pike)
Etheostoma asprigene	(Mud darter)
Etheostoma chlorosomum	(Bluntnose darter)
Etheostoma exile	(Iowa darter)
Fundulus dispar	(Starhead topminnow)
Ictiobus cyprinellus	(Bigmouth buffalo)
Lepisosteus oculatus	(Spotted gar)
Lepomis gibbosus	(Pumpkinseed)
Lepomis gulosus	(Warmouth)
Lepomis miniatus	(Redspotted sunfish)
Lepomis symmetricus	(Bantam sunfish)
Notemigonus crysoleucas	(Golden shiner)
Notropis anogenus	(Pugnose shiner)
Notropis chalybaeus	(Ironcolor shiner)
Notropis heterolpeis	(Blacknose shiner)
Notropis texanus	(Weed shiner)
Noturus gyrinus	(Tadpole madtom)
Opsopoeodes emilae	(Pugnose shiner)
Percina caprodes	(Logperch)

Methods of Obtaining and Stocking Fish Species and Their Assessment

Stocking Methods and Strategies

Most of the species were obtained within the Illinois River Valley. A few species that were stocked in Spunky Bottoms originated from the lower Kaskaskia River and Cahokia Creek, which are drainages to the Mississippi River just to the south of the Illinois River. These species were the Grass pickerel (*Esox americanus*), Mud minnow (*Umbra limi*), Tadpole madtom (*Noturus gyrinus*) and Pirate perch (*Aphedoderus sayanus*). There was no evidence that these populations were different genetically from the Illinois River populations, and the populations were within an easy transport distance to Spunky Bottoms. Some of the sunfish species were obtained from sites along the Mississippi River.

Most of the species stocked into Emiquon originated within a short distance to that site. The Crane Creek system (Mason County) was a rich source of small nongame species such as Starhead topminnow (*Fundulus dispar*), Lake chubsucker (*Erimyzon sucetta*), Mud minnow (*Umbra limi*), and Grass Pickerel (*Esox americanus*). Just to the north of Emiquon on the west side of the Illinois River is the Rice, Big, and Goose Lake system (Fulton Co.). A number of species were obtained there such as the Logperch (*Percina caprodes*), Orangespot sunfish (*Lepomis humilis*), Bowfin (*Amia calva*), Tadpole madtom (*Noturus gyrinus*), and Mud darter (*Etheostoma asprigene*). Spring Lake (Mason Co.) is located on the east side of the Illinois River across from Big Lake.

This lake was the source for Spotted gar (*Lepisosteus oculatus*) and Brown bullhead (*Ameiurus nebulosus*).

For Hennepin-Hopper, most of the species came from local small direct tributaries of the Illinois River, the Vermilion River (Illinois River tributary), and Beaver Creek (Iroquois River, an Illinois River tributary).

Of the 35 species stocked, most were obtained within a short distance of the stocking site. The significance of this means that when restoring sites along the Illinois River, a wide variety of species is available for stocking. The close sources mean that individuals can be transported to stocking sites with limited mortality and concerns about appropriate genetic composition of the stock is limited.

Originally, the thought was to use pens or enclosures for adults to spawn in and subsequent release of young in the lake. This method was first tried using Orangespot sunfish (*Lepomis humilis*) in Hennepin-Hopper and further refined at Emiquon (see the Orangespot sunfish account for more details.) While the method can work for single species, it quickly became evident that the use of brooding ponds near to stocking sites or ditches on the sites is a very effective way to raise stock for stocking into the main lake especially for species that can only be obtained in small number (see the Starhead topminnow account for an excellent example). The Starhead topminnow is a state threatened species and to avoid taking individuals from the wild, stock was obtained from experimental brood ponds established by IDNR fisheries biologists. From these we were able obtain a larger number of individuals for direct stocking at Hennepin Hopper and for stocking an isolated ditch at Emiquon.

Advantages of stocking an onsite ditch/pond include the close proximity to the final stocking area (short transport time and distance), low cost relative to enclosures, and a large numbers of individuals can be raised within a fairly short period of time depending on the species. The downside is that ditches and ponds are generally not designed for easy removal of the stock. Often brush and steep banks make collecting the stock difficult. Ditches in particular are connected to other ditches or the main lake by tiles. This connection may permit movement out of the ditch of the desired stock or possibly worse, incoming predators or competitors into the ditch. In the case of Ditch KK, at Emiquon, the tiles may have permitted the survival of mosquitofish (*Gambusia affinis*) and Black bullhead (*Ameiurus melas*) in the ditch after removal of unwanted species by rotenone. Also, the water levels changed drastically at Spunky Bottoms and Emiquon where water control was limited. Ditches and ponds are vulnerable to drying out or being flooded out. In the latter case, this could be a strategy for stocking if water levels can be manipulated. That is, a sizable population of stock could be established and the stock be permitted to leave the ditch by raising water levels. This situation occurred with the Starhead topminnow in the area around ditch KK.

Some ditches that were used as brooding sites did dry up in 2007 from low rainfall. The bottom line here is that water levels in the lakes can change significantly in a year's time. Enclosures can avoid changes in water levels in that they can be designed to be portable. Unlike ditches/ponds, there is an associated cost in their construction and they are unlikely to survive more than a few seasons. However, if no ditches/ponds are readily available, enclosures are likely to be far less expensive than the construction or modification of ditches or ponds. Given the success of the brood ditch and pond at

Emiquon, using a similar setup is being considered at Hennepin Hopper after its rehabilitation in 2010 (G. Sullivan, TWI).

Various methods were used to collect material for stocking. This included the use of seines (minnow and bag), trap nets (minnow traps and fyke nets), dipnets, backpack electroshockers, barge electroshockers, and boat electroshockers. Effectiveness of methods was dependent on the species sought, seasonal timing, and the habitat that they occurred in. Methods are further discussed under the species accounts, but in general all can be effective in the right situation.

Overall success was lowest for minnow traps for gather stocking material. They were used to trap species such as the Central mudminnow (*Umbra limi*) which occur in habitats (heavy vegetation and soft bottoms) hard to sample. However, this species seemed not vulnerable to traps perhaps because they do not move far within their habitat. Indeed when they were used for general monitoring, the traps were very effective for other species (see below). The minnow traps nets used were collapsible, relatively inexpensive, and had a 1/2 inch or fine mesh. They were easily transported and fairly durable and a single person can set and retrieve them. Floats (empty water bottles) were attached the fine mesh traps to make them float so as sample the topwater zone. Information about the manufacturer is available from the M. Retzer.

Minnow and bag seines were used and each had their advantages. Each was effective in wadeable areas with low or no aquatic vegetation or other obstructions especially in ponds and small streams. They were used to capture small-bodied species such as Orangespot sunfish (*Lepomis humilis*) and Johnny darters (*Etheostoma nigrum*). Because individuals could be immediately placed in holding containers and moved to another location, mortality was low in general. The minnow seines were 10 to 15 feet in length with 1/4 to 1/8 inch mesh. The bag seines were 20 to 30 feet in length with 1/4 to 1/8 inch mesh. Minnow seines can be relatively inexpensive although a good bag seine may cost about $300 (information about the manufacturer is available from the M. Retzer). Both are easy to learn how to use although results are better when used by experienced field staff. Seines can be easily repaired and may last two or three field seasons. Bulkier than collapsible minnow traps they require two people to operate the net efficiently. A third person is also useful for following the net to release it from snags and to carry holding container

Traps nets (fyke nets) were used in the Big Lake area, Spring Lake, a backwater near to Hardin, Illinois, and a pond at Allerton Park, Piatt County, IL. Large nets were set to capture large bodied species particularly Bowfin (*Amia calva*), Brown bullhead (*Ameiurus nebulosus*), and Spotted gar (*Lepisosteus oculatus*). Minifyke nets were used at Allerton Park to capture smaller species: Lake chubsuckers (*Erimyzon sucetta*) and Starhead topminnows (*Fundulus dispar*). The nets can be fairly large and expensive (over $350). Like seines they can be easily repaired and maintained for several seasons. The larger nets may require two people to set and retrieve the nets. The large nets are often set from a boat that provides access to distant areas and can carry a large holding container for the fish. Trap nets can be very effective for some species and require expertise on how, when, and where to set them.

Three types of electroshockers were used with good success for several species when used appropriately. The backpack shocker was effective especially for Pirate perch (*Aphredoderus sayanus*), Grass pickerel (*Esox americanus*), and Central mudminnows

(*Umbra limi*) in small streams. It worked well in shallow areas with a fairly firm substrate and heavy to no vegetation. The shocker itself can be heavy and difficult to carry on soft substrates. Of the three shockers, it is the least powerful and may ineffective in water with very high or low conductivity. However, the low power reduces stress and mortality on the fishes. The backpacker electroshocker, like the other electroshockers used, is very expensive (many thousands of dollars) and requires a high degree of skill to use safely and to maintain. As the names imply, barge and boat electroshockers have generators floating on a barge that is pushed through the water by two or three waders or mounted on a boat. Electrodes extend into the water ahead of the boat or barge. Each electrode transmits a high voltage into the water to stun the fishes. This method is very effective for most fishes although boat shockers may miss deeper benthic species. In general, mortality is low but it was observed in a small stream that a barge shocker could inflict high mortality. The result was likely due to the restricted space that the fishes had to move in.

When fishes were captured, they would be placed in a temporary holding container (a bucket when seining or large tank on a boat for instance). They were immediately transported to large cool or stainless steel tank in or a truck or van. Oxygen was provided to the fishes by a battery powered airpump or oxygen tank. Oxygen supply was critical for reducing mortality especially when air and water temperatures were high. Collecting stock was most effective early and late in the year. Mortality would increase when air temperatures increased above 90^{o} F. The number of individuals stocked was recorded and often individuals were measured (total lengths) and weighted. Whether individuals were weighted and measured was often determined by the condition of the individuals. If the fishes appeared stressed, they would be immediately stocked or acclimated to new water temperatures and then stocked.

The timing of gathering stock was also related to the spawning and growth of the young. If adults can be obtained in early spring before spawning, the species can have a head start if they spawn soon after being stocked into a lake. In late summer or fall, young-of-the-year may be collected in high numbers and translocated to a lake. In late summer high vegetation densities may enhance this strategy by providing protection from predators and a food source.

Assessment Methods and Strategies

The method used to assess stocking success was dependent on which species was being assessed. Many of the methods used to collect the fishes were the same used to obtain fished for stocking. Many of the methods used to survey the fishes were the same ones that were used to obtain the fish for stocking.

Although the minnow traps were relatively inefficient in the capture of some species, they worked very well in the capture of sunfishes, catfishes (non-stocked species), and bowfin. Generally, we did not bait the traps so to avoid capturing turtles or high numbers of non-target species (e.g., black or yellow bullheads). Minifyke nets were also used in assessments and were particularly effective in capturing sunfish. Large fyke nets were effective in collecting larger bodied sunfish and largemouth bass. Care was required in placing where the top of the net was above the water. We discovered that at night, oxygen levels in the shallow areas fell substantially and could cause mortality of individuals in the nets. This diurnal-nocturnal change in oxygen was most evident in

Emiquon. This daily cycle was unexpected as levels monitored in deeper areas of the lake did not show this pattern (M. Lempke, TNC, pers. comm.). Care should be taken in the future to recognize this phenomenon in future fish restoration projects.

We used boat electroshocking extensively on the lakes and it was effective in detecting many of the species stocked. The method was less effective in deeper water and ineffective on topminnows (*Fundulus* sp.). Depths greater than about 10 feet were not sampled primarily because most of the target species were expected to occur at shallower depths.

We tested a backpack shocker at Emiquon and found it to be ineffective in detecting species present. The situation was likely the combination of lower power output with the water conductivity level in the lake and the dense vegetation coverage. So we suggest that this method not be used to assess these types of lakes.

We did find that visual searches in combination with a dipnet was effective in detecting common sunfishes. The Starhead and Blackstriped topminnows were easily seen visually. This method is especially useful in water too shallow for boat electroshocking and where vegetation is too dense for seining.

We also experimented with snorkeling (with an underwater camera) and sound to detect the stocked species. Based on the high water clarity that had been seen at Hennepin-Hopper before the project began, snorkeling was considered a viable method to assess the lakes' fish species. However, the turbidity in all of the lakes was too high to effectively see fish more than a couple feet even in the best conditions. This method should still be considered as an option if turbidity levels become lower. The method has been tested elsewhere and is considered valid. It incurs a low impact cost on the fish community.

Sounds to detect various species of birds and amphibians have long been used for study presence of these animals. The use of sounds in the aquatic community is still in its infancy. With increased computing power of desktop computers, very sophisticated computer programs are now available to monitor animal communities, most extensively with birds. Sounds of a few freshwater fish species have been recorded (Johnston et. al., 2008). However, most of the species stocked during this study have not been recorded. To use sound to monitor a fish community, a species sound or set of sounds must be prerecorded and placed into a library. The software then searches the recordings taken in the field for sound patterns that match sounds in the library.

We used an H2a-XLR-3 hydrophone and Rolls LiveMix preamplifier from Aquarian Audio Products to pick up sounds *in situ* and in containers. The LiveMix transfers the sound to Sony voice recorder (MP3 IC Recorder). The setup costs less than $300 and is easily transported and used under field conditions. For our purposes, this setup was suitable for our purposes of making recordings and determining if this would be a valid monitoring and assessment tool. More expensive and sophisticated hydrophones and amplifiers are available from a number of dealers. The sound files were transferred from the recorder to a desktop computer, in this case, an iMac computer. We made recordings from the Bowfin (*Amia calva*), Brown bullhead (*Ameiurus nebulosus*), Lake chubsuckers (*Erimyzon sucetta*), Green sunfish (*Lepomis cyanellus*, note this was not a target species), Redspot sunfish (*Lepomis miniatus*), Warmouth (*Lepomis gulosus*), and Starhead topminnow (*Fundulus dispar*). Individuals of each species were placed into

a bucket and any sounds produced were recorded in 5 to 15 minute intervals. Presumptive sounds were recorded for all of the species except the Starhead topminnow.

An example of a spectrograph for the Lake chubsucker (*Erimyzon sucetta*) is illustrated in Figure 1. These sound files can then be used by computer programs to recognize these species from field recordings (see below for general recording form the field, Fig. 2). We were not able to use this method for assessments of the lakes, however, it is potentially a valuable method for assessments. Potential benefits of this method when fully developed are that it is relatively inexpensive, a relatively unobtrusive means of gathering information, and can be targeted to species difficult to sample (i.e., benthic species in deep water or species in dense aquatic vegetation).

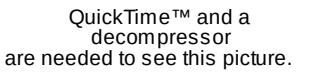

Figure 1. Spectrograph of a sound (dark region at 9:37.6) produced by a single Lake chubsucker (*Erimyzon sucetta*). The X axis is time in minutes:seconds, Y axis is kHz. Waveforms and raw sounds files for the other species are available from the PI.

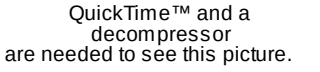

Figure 2. Spectrograph of a sound (dark regions at 3:38.7, 3:39.07, 3:39.17and recorded at Thompson Lake on August 11, 2009. Source of the sound is unknown. The X axis is time in minutes:seconds, Y axis is kHz. Waveforms and raw sounds files for the other species are available from the PI.

The spectrographs illustrated here were generated by a free software program from Cornell Lab of Ornithology (www.birds.cornell.edu/brp/raven/RavenOverview.html). The RavenLite program is useful to study, identify, and characterize sounds in order to build a library. A more

sophisticated version of Raven is required to use a library to scan recordings from field sites. See also the Wildlife Acoustics, Inc website (www.wildlifeacousitcs.com) for more sophisticated hardware and sound analysis

A good example of the use of sounds for monitoring is a program at the University of Hawaii being done by Dr. Tim Tricas with reef fishes off of Hawaii. This is an ambitious effort that has built a library of sounds for 70 species of fishes and has recorded the sounds daily for over one year (T. Tricas, pers. comm.). Not only can he detect the presence of these species, he can gather behavioral information because these fishes generate sounds related to their behaviors. Species of *Lepomis* sunfishes are known to generate certain sounds during spawning, and they will likely generate others that reflect other social activities (Johnston et. al., 2008). Hence, sounds may produce a rich source of information on the activity of fish species.

In addition, total noise recordings can be used to assess overall community health or comparison purposes with other lakes or over time. Fishes not only makes sounds within aquatic communities. Aquatic insects also make sounds but the use of sound to study aquatic insects is also in its infancy (Paul Tinerella, INHS, pers. comm.). Drs. Retzer and Tinerella are exploring ways to continue this line of work.

The early detection of exotic or invasive fish species with this method could also be very beneficial for resource managers.

Stocking and Assessments of the Lakes

Hennepin-Hopper lakes, Putnam County, IL

The Hennepin and Hopper lakes (approx. 41^{o} 12’ 24.9”N, 89^{o} 19’ 54.1”W, Fig. 3) were once sloughs of the Illinois River that were drained and converted into farmland and separated from the river by a levee. The bottomland was re-flooded in 2001 after effort was made to remove the fish community that had become established in the ditch system. Of particular interest was the removal of the Common carp (*Cyprinus carpio*). For the first five years, the aquatic community flourished with establishment of the plants and stocking of common native sport fishes. When this project began, the lakes (currently a single lake), were the most advanced in terms of restoration with a highly diverse aquatic plant community and clear water. Because of the pumps, water level could be controlled for management purposes.

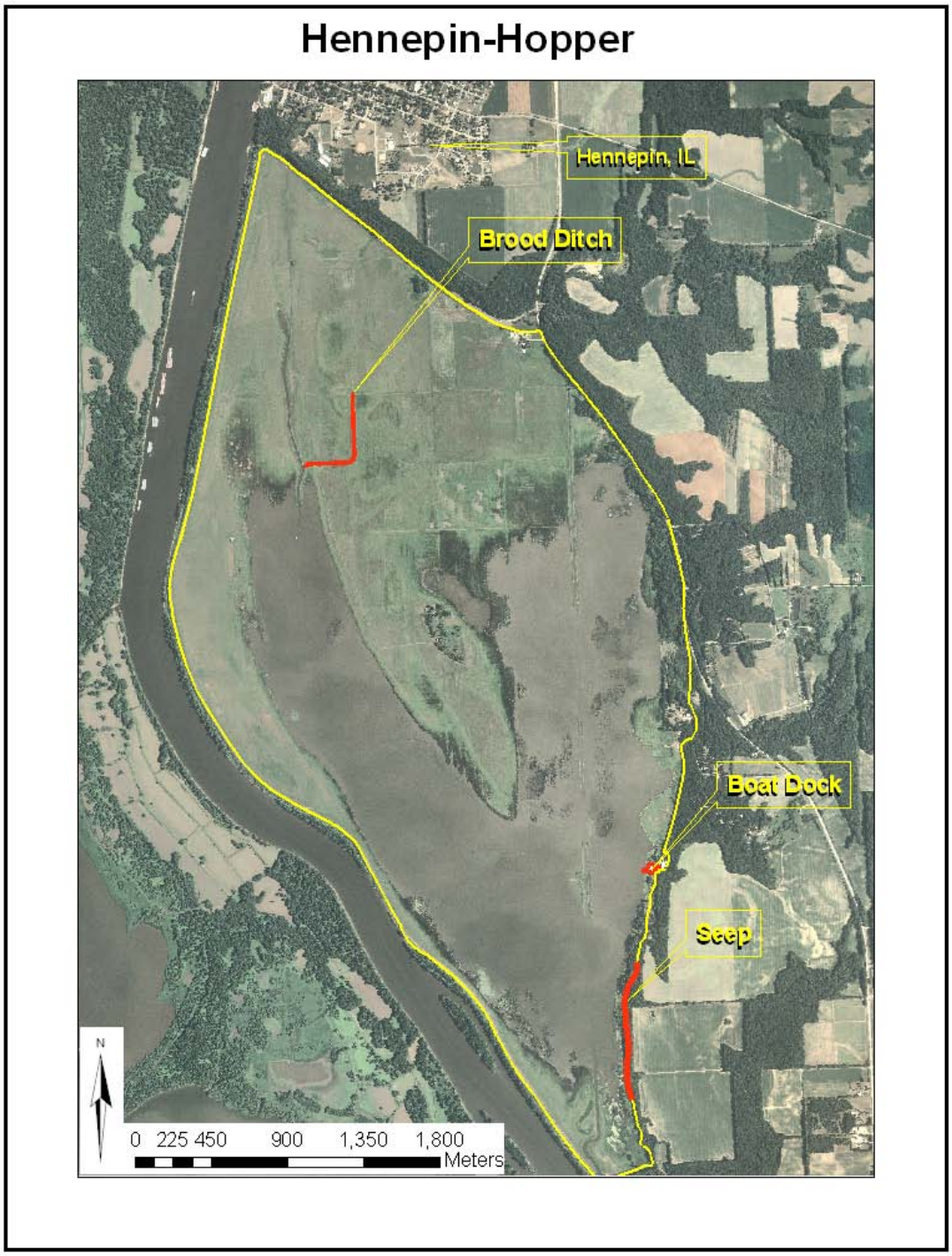

Figure 3. Map of Hennepin-Hopper Lakes, Putnam Co., IL.

Since 2006, the lakes have undergone a startling transformation. Not all of the carp had been eliminated during the original rehabilitation of the lakes. It is difficult to know why for certain, but the carp population exploded (Fig. 4) and was followed by a drastic decline in the aquatic plant community. Because of this change in the community,

stocking was limited to 2007. The IDNR and TWI have been announced plans for the lake to drain again and the carp to be removed during the spring of 2010 (http://www.wetlands-initiative.org/HHNews.html). While this result was a disappointment, it teaches us of the problems that can arise with restoration of large floodplain systems. While a study of carp of these lakes is not the focus of this project, carp is discussed within context of the assessment of the lake stockings below. The positive experience of the project at Emiquon will influence the restoration effort at Hennepin-Hopper that will follow the rehabilitation of the lakes in 2010. Also, the events at Hennepin-Hopper may influence further management at Emiquon because a small population of Common carp remains at Emiquon.

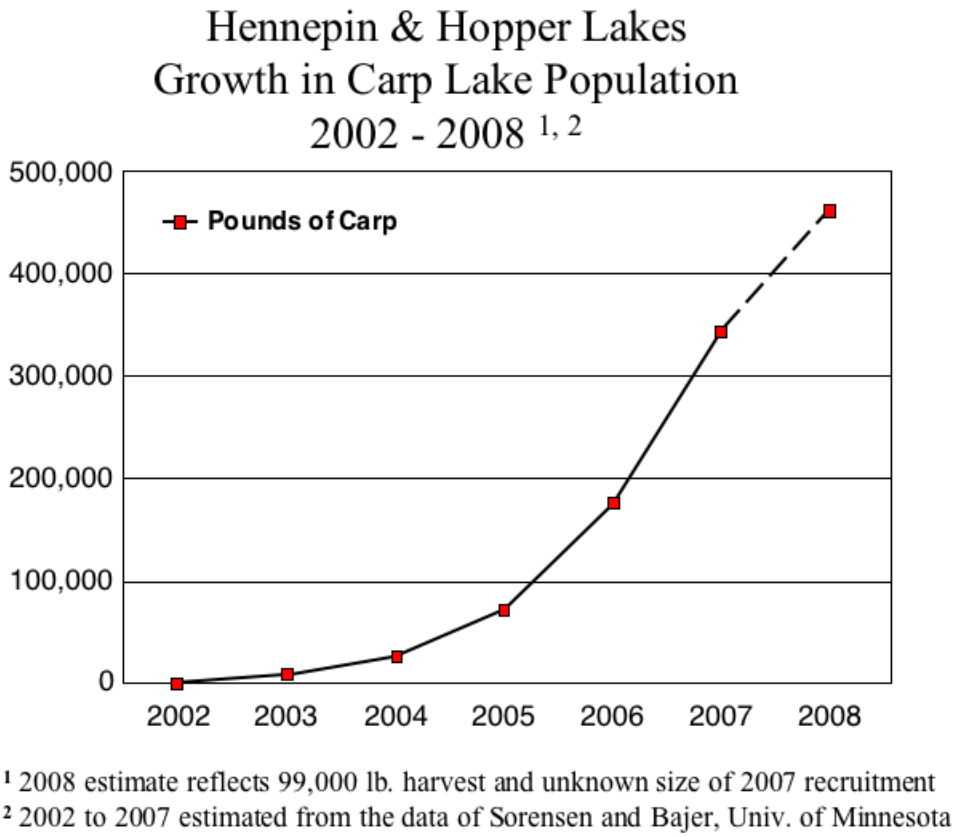

Figure 4. Growth in the Common carp (*Cyprinus carpio*) population at Hennepin-Hopper Lakes. Graph courtesy of The Wetlands Initiative, Chicago, IL.

Stocking of Hennepin-Hopper Lakes

A total of eight species were stocked into the Hennepin-Hopper lakes. These five species were stocked in the highest numbers: Brown bullhead (*Ameiurus nebulosus*) Pirate perch (*Aphredoderus sayanus*), Starhead topminnow (*Fundulus dispar*), Orangespotted sunfish, (*Lepomis humilis*), and logperch (*Percina caprodes*). But these five species were stocked in small numbers relative to Emiquon (Table 2, Appendix 1a, see Table 3 for relative numbers stocked at Emiquon). The Grass pickerel (*Esox*

americanus) were not likely stocked in sufficient numbers to start a population, and the low density would have made detection unlikely for the first few years.

The stocking of the lake proceeded in 2007 by direct stocking of the southeast margin of the lake that included the seep area (Fig. 3). The seep in particular was selected for the Starhead topminnow. A ditch in the northwest corner was isolated from the main lake for use as a brood ditch for other species for the main lake in 2008.

In 2007, the increasing population of Common carp (*Cyprinus carpio*) became an obvious concern because of the damage they could cause. By 2008, it was obvious by the increased turbidity and loss of aquatic vegetation that the lake was suffering a catastrophic cascade of events. We then decided to end further stocking but to monitor the species that were stocked. Ending the stocking greatly limited the number of species and individuals that we had hoped to stock.

Table 2. List of all species stocked and numbers stocked in Hennepin-Hopper lakes.

Species		Number of Individuals
Ameiurus nebulosus	(Brown bullhead)	50*
Aphredoderus sayanus	(Pirate perch)	25
Esox americanus	(Grass pickerel)	11
Etheostoma nigrum	(Johnny darter)	1
Fundulus dispar	(Starhead topminnow)	69
Fundulus notatus	(Blackstripe topminnow)	1
Lepomis humilis	(Orangespotted sunfish)	57
Percina caprodes	(Logperch)	56
Umbra limi	(Central mudminnow)	3

*This target species was previously stocked into the main lakes by IDNR.

Assessment of the Stocking of Hennepin-Hopper Lakes

The area from just north of the boat launch to the south end of the seep was visually searched in combination with a dipnet on three occasions (Fig. 3). The area was searched primarily for Starhead topminnows (*Fundulus dispar*) that were stocked primarily in the seep area. The search was made both by wading and from kayak. Fine meshed minnow traps (rigged for floating) were also placed into the seep on one occasion. None of the species stocked in the area (Starhead topminnows, *Fundulus dispar*, Central mudminnows, *Umbra limi*, Orangespotted sunfish, *Lepomis humilis*) were found. Several reasons for not finding them are possible. All three species were stocked in low numbers especially the Central mudminnow (*Umbra limi*). Stocking numbers were limited when the lake system became distressed. Still, most of the topminnows were placed in the seep area as it was thought to be a protective area for these species to become established. The area is typical of a seep with a constant flow of water from the base of the bluff. Although water would gather in shallow pools in a mix of cattails, submergent vegetation was conspicuously missing. At Emiquon, Starhead topminnows were established in areas with abundant aquatic vegetation. Water temperatures could

play a role in that seep water is constant and colder that in typical shallow areas of these lakes. Perhaps the water temperatures here were too cool for the topminnow.

The brood ditch that was isolated from the main lake had been stocked with Pirate perch (*Aphredoderus sayanus*), Grass pickerel (*Esox americanus*), Johnny darter (*Etheostoma nigrum*), Blackstripe topminnow (*Fundulus notatus*), and Logperch (*Percina caprodes*) (Fig. 3). It was boat electroshocked after it was evident that efforts to isolate it from the lake failed. None of these species were found although high numbers of large predator species Largemouth bass (*Micropterus salmoides*) and White crappie (*Pomoxis annularis*) were captured in the ditch. Any chance that any of the stocked species survived was highly unlikely.

In fall of 2009, in preparation for a total rehabilitation of the lake, water levels were lowered and the game fishes assessed and removed for restocking after rehabilitation. During this process, Brown bullheads (*Ameiurus nebulosus*) were found to occur in fairly high numbers. See the Brown bullhead species account for more information on this and other species. None of the other stocked species were noted (W Herndon IDNR, pers. comm.).

Emiquon (Thompson-Flag Lakes), Fulton County, IL

The Thompson and Flag lakes at Emiquon (approx. 41^{o} 13' N, 89^{o} 20' W, Fig. 5) were bottomland lakes of the Illinois River that were drained in 1923. They were converted into farmland and separated from the Illinois River by a levee (Havera et. al., 2003). Rehabilitation of the lakes began in 2007 to remove a ditch fauna comprised of Common carp (*Cyprinus carpio*), Grass carp (*Ctenopharyngodon idella*), Goldfish (*Carrasius auratus*), buffalo (*Ictiobus* sp.), Freshwater drum (*Aplodinotus grunniens*), and bullheads (*Ameiurus* sp.), and a variety of sunfish species and largemouth bass. Stocking of fish species began that spring. At the beginning, water levels rose slowly and lack of rain actually dried out some of the outer ditches (a few of which had been stocked by us). Figure 5 shows the system of ditches present in 2007, and most if not all of the ditches were subsumed into the main lake by 2009.

In 2008, water levels began to rise dramatically from about 1,000 acres to almost 5,000 acres at the present time. This area of water was largely unanticipated although 2009 saw very high amounts of rainfall (T. Hobson, TNC, pers. comm.). Most of the ditch before the rehabilitation, lacked sub- and emergent aquatic vegetation due to the exotic fish species. However post rehabilitation vegetation soon became established and has spread dramatically through the system. Most of the ditch at the beginning lacked sub- and emergent aquatic vegetation. However, vegetation soon became established and has spread dramatically through the system. The vegetation was necessary for the establishment of many of the species that we stocked.

The rapid changes in the system were interesting to observe. The invasion of the shallow areas was quickly followed by aquatic insects and snails. Snail populations appeared to fluctuate greatly from low to very high to low densities within a few months. Mosquitofish (*Gambusia affinis*) survived the lake rehabilitation and quickly became abundant in 2008. We noted very high numbers again in spring of 2009 in shallow areas of the west side of the lake. By summer, the species had largely disappeared. All of this suggested a rapidly evolving and probably unstable system. It remains unknown if

stocking of this number of species early in the restoration will increase the success of their stocking or perhaps they have increased or decreased the stability within the lake.

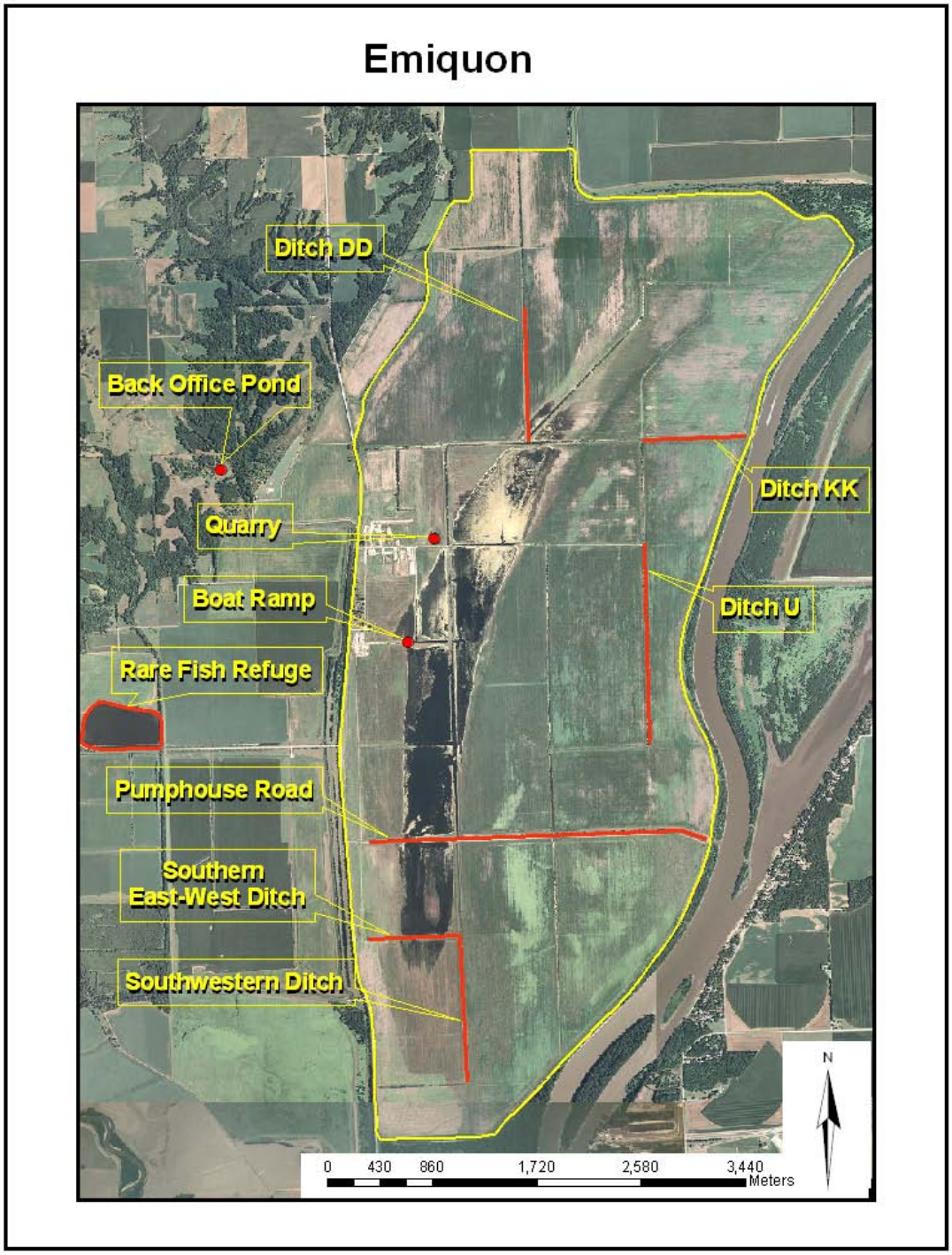

Figure 5. Map of area containing Thompson/Flag lakes (enclosed by yellow border) (Fulton Co.), and other stocking areas of note.

In addition to the Thompson and Flag lakes, we used the back office pond for rearing near the THC headquarters (40° 21' 47"N, 90° 5' 56"W, Fig. 5), and we cooperated with the establishment of a rare fish refuge (40° 20' 38"N, 90° 6' 36"W, Fig. 5) just west of Thompson Lake. With Trent Thomas (IDNR), Rob Hilsabeck (IDNR), and Tharran Hobson (TNC), this small fishless lake was stocked with Starhead topmimmows (*Fundulus dispar*) and Redspotted sunfish (*Lepomis miniatus*). This lake is providing a refuge for rare species in the state and may provide future stock for other restoration/translocation projects in Illinois.

Thompson and Flag lakes (now one lake) are making excellent progress in the restoration process. However, it is still early in the process and it remains to be seen how the lake will look in ten or twenty years. Related to this project, we are concerned with the appearance of Common carp (*Cyprinus carpio*) in Thompson and Flag lakes. If the events of Hennepin-Hopper are a guide, the re-establishment of the species at Emiquon could ultimately lead to disastrous results there. The carp population at Emiquon requires close monitoring to prevent such an occurrence. The Common carp (*Cyprinus carpio*) is a major impediment to these projects and their management requires much greater study. We hope that the establish of a diverse native fish community at Emiquoun will test the idea that diverse communities are more stable and resistant to major declines.

Stocking of the Emiquon Lakes

The total number of species that were stocked (31) was far higher than we had anticipated. There were a few reasons for this. First, the extra efforts of Rob Hilsabeck (IDNR) and Wayne Herndon (IDNR) to acquire many of the species insured that many species would be obtained for stocking. It was also their intimate knowledge of the local lakes that helped locate sources for several species. Secondly, we were fortunate that some of the small species (e.g., Pirate perch, *Aphedoderus sayanus*, Mudminnow, *Umbra limi*, Starhead topminnow, *Fundulus dispar*, and Lake chubsucker, *Erimyzon sucetta*) could be found together in nearby small streams (primarily Crane Creek in Mason County). This project also coincided with efforts by Gary Lutterbie (IDNR) and Trent Thomas (IDNR) to establish experimental brood ponds for Starhead topminnow (*Fundulus dispar*), and Lake chubsucker (*Erimyzon sucetta*). These ponds provided stock for Emiquon.

A total of 31 species were stocked into the Emiquon lakes, primarily the Thompson and Flag lakes (Table 3). The Brown bullhead (*Ameiurus nebulosus*) and Starhead topminnow (*Fundulus dispar*) also were stocked in the back office pond. The Starhead topminnow and Redspotted sunfish (*Lepomis minatus*) were also placed in the rare fish refuge. Note that the Redspotted sunfish has not yet been stocked into Thompson-Flag lakes. A total of 30 species were stocked into Thompson and Flag lakes. Nineteen species were stocked in excess of 100 individuals and five species were stocked in relatively low numbers, less than 20 individuals (Table 3). Theoretically, only one male and one female is required for reproduction but in very large lakes with heavy predation especially from largemouth bass and crappie, these five species seem unlikely to start a sizable population. (See the assessment section below for more on this.) However, most of the species were stocked in numbers that will give them a reasonable chance of success although it may be a few years until they reach detectable levels. The

lake has increased to a very large size and this will make detection of rare species more unlikely.

In 2007, several sunfish and crappie species were stocked directly into Thompson Lake. These species came from a variety of areas including the Hennepin-Hopper lakes, Banner Marsh (Fulton-Peoria Counties), and Big Lake (Fulton Co.). However, a series of ditches on the east side including ditch KK (Fig. 5) were stocked with a variety of species including Bowfin (*Amia calva*), Central mudminnow (*Umbra limi*), Starhead topminnow (*Fundulus dispar*), and Lake chubsucker (*Erimyzon sucetta*). Some of the ponds dried out unexpectedly although attempts were made to remove stock but this was not successful. It was unknown if the fishes were removed by predators or if they escaped by a tile system to other areas of the lake. Curiously, bowfin was found in Thompson Lake later that year, and they could have originated from one of these ditches that dried out. This suggests that tile systems at restorations sites are a management issue and every effort should be made to at least know where they occur and how they may help or hinder a restoration.

In fall, 2007, ditch KK became a source of brood stock for Starhead topminnow (*Fundulus dispar*) and Lake chubsucker (*Erimyzon sucetta*) for the back office pond. We moved 142 Starhead topminnows and 29 Lake chubsuckers from the ditch to the pond. A total of 23 Brown bullheads (*Ameiurus nebulosus*) were also stocked into the back office pond from Spring Lake (Mason Co.). Moving the quickly Starhead topminnows to the pond illustrates quickly the species could reproduce in one season. However, of the three species in the pond, only the Starhead topminnow multiplied in high numbers.

In 2008, about 4,500 topminnows were seined from the pond and directly stocked into Thompson Lake. The other two species had poor reproduction in the pond and this suggests they may not be easy to propagate in ponds (see species accounts for these species). The Mosquitofish (*Gambusia affinis*) was also inadvertently stocked with the topminnow. Efforts had been made to remove them before stocking but trying to limit the stress on the topminnows during the translocation allowed some Mosquitofish to slip through. They also became well established in the back office pond. This exemplifies the need to take precautions to prevent stock contamination. In this case, the Mosquito fish may inhibit the Starhead topminnow reproductive success (Laha and Mattingly, 2007, see the Starhead topminnow account for more information.) Also in fall, 2007, a small number of Starhead topminnow (*Fundulus dispar*), and Lake chubsucker (*Erimyzon sucetta*) were directly stocked into the SW area of the lake. Brown bullhead recruitment was good by 2009. Harvest techniques to collect fish from the pond need to be tested and may utilize spring trap netting as the most effective.

Table 3. List of species stocked and numbers stocked at Emiquon during this project.

Species		Number of Individuals
Ameiurus nebulosus	(Brown bullhead)	166
Amia calva	(Bowfin)	42
Aphredoderus sayanus	(Pirate perch)	117
Erimyzon sucetta	(Lake chubsucker)	291
Esox americanus	(Grass pickerel)	156
Etheostoma asprigene	(Mud darter)	55
Etheostoma nigrum	(Johnny darter)	73

Fundulus dispar	(Starhead topminnow)	9,301
Fundulus notatus	(Blackstripe topminnow)	498
Ictalurus punctatus	(Channel catfish)	106
Labidesthes sicculus	(Brook silverside)	600
Lepisosteus oculatus	(Spotted gar)	56
Lepisosteus osseus	(Longnose gar)	14
Lepomis gibbosus	(Pumpkinseed)	300
Lepomis gulosus	(Warmouth)	80
Lepomis humilis	(Orangespotted sunfish)	959
Lepomis macrochirus	(Bluegill)	2,259
Lepomis miniatus	(Redspotted sunfish)	~4,000*
Micropterus salmoides	(Largemouth bass)	1,274,163**
Notemigonus crysoleucas	(Golden shiner)	110
Notropis atherinoides	(Emerald shiner)	150
Notropis hudsonius	(Spottail shiner)	8
Noturus gyrinus	(Tadpole madtom)	43
Percina caprodes	(Logperch)	85
Percina maculata	(Blackside darter)	5
Percina phoxocephala	(Slenderhead darter)	4
Pomoxis annularis	(White crappie)	152
Pomoxis nigromaculatus	(Black crappie)	4,330
Sander canadensis	(Sauger)	20
Sander vitreus	(Walleye)	410,000**
Umbra limi	(Central Mudminnow)	221

*These were raised in an INHS experimental pond by T. Thomas (IDNR) and J. Epifanio (INHS).
**These were fry from Jake Wolf hatchery.

In 2008, in addition to the work at ditch KK and back office pond, the Starhead topminnow (*Fundulus dispar*) and Redspotted sunfish (*Lepomis miniatus*) were stocked into the newly established rare fish refuge (Fig. 5). Other species also were directly stocked into Thompson/Flag Lakes (Appendix 1b). By 2009, stocking efforts were greatly reduced, and the focus was switched primarily to assessing the success of the stockings.

We attempted to stock some species in areas where we thought the habitat was most appropriate. For example, logperch were placed in or near an old gravel pit and around old gravel road because the species prefers sand and gravel substrates. Starhead topminnow (*Fundulus dispar*), and Lake chubsucker (*Erimyzon sucetta*) were placed in shallow areas with abundant stands of submergent vegetation. See "Assessments" below for more comments on this strategy.

The total number of fish stocked (N=1,704,364) was highly skewed by the high number of Walleye (*Sander vitreus*, N=410,000) and Largemouth bass (*Micropterus salmoides*, N=1,274,163) stocked into the lake. Not counting the Walleye and Largemouth bass, 20,201 individuals were stocked. All of the Walleye and most of the Largemouth bass were stocked as fry. Collecting fry from wild populations was too

difficult and costly so these were obtained from the Jake Wolf Hatchery located a few miles to the east of Emiquon.

Assessment of the Stocking of Emiquon

Preliminary surveying of the area began in fall of 2007 when Starhead topminnow (*Fundulus dispar*), and Lake chubsucker (*Erimyzon sucetta*) were found in ditch KK and some were removed for stocking elsewhere at Emiquon. These species had reproduced in the ditch, verifying that use of ditches is a viable means of generating stock. Ditches were also sampled by boat electroshocking to reveal limited numbers of sunfishes and locally abundant crappie species at the south end of the lake. Largemouth bass, stocked by IDNR, were also present. Two species, black bullhead (*Ameiurus melas*) and Goldfish (*Carassius auratus*) were also captured. These two species were not stocked, but were survivors from the pre-rehabilitation fish community.

Assessment activities increased in 2008 and again in 2009 using boat electroshocking, backpack electroshocking, visual search with dip nets, minnow traps, and minifyke nets. During this time period, lake levels increased significantly. Water in the ditches rose and spilled onto surrounding fields and created an extensive shallow water habitat. The aquatic vegetation quickly followed into the newly created habitats. This new habitat appeared highly suitable for many of the species selected for stocking.

Fifteen species were detected at Emiquon after stocking and 13 species were deemed to be reproducing based on presence of young fishes (Table 4). The number of species surviving at Emiquon is 48% of the total number species stocked. The number of species reproducing at Emiquon is 42%. We believe that these numbers indicate a reasonable level of success. Unfortunately, there are no comparative studies like this to base these results upon. Indeed, this project will establish the benchmark for other such projects. Recalling that some species were stocked in low numbers (<20), this rate of establishment seems even more indicative of success. In total, we far exceeded our goal of four to six species. Problems at Hennepin-Hopper makes comparisons with that project inconclusive, however, Spunky Bottoms had no such problems and comparisons with that lake are discussed under that section.

It is worthwhile to note that none of the species stocked in low numbers (<20, Table 4) were ever detected. In general, species that were stocked in higher numbers were more likely become established at least for some period of time. However, there were exceptions to this observation. The Walleye (*Sander vitreus*) was stocked in very high numbers, they have yet to be detected. They were stocked as fry that are very vulnerable to predation (R. Hilsabeck, IDNR, pers. comm.). In contrast, only 42 Bowfin (*Amia calva*) were stocked into Thompson Lake, and they quickly established a breeding population. In the end, it is not necessarily the number that are stocked, but the number required to establish a breeding population. Success is also dependent on size, age, and timing of stocking for each of the species. In addition, life history traits may be important. In the case of the Bowfin (*Amia calva*), the species has highly developed parental care insures a high rate of reproductive success.

Table 4. List of species observed at all Emiquon sites (including the rearing pond and rare fish lake) 2008-2009. p = present, r = reproduction evident

Species	Status
Amia calva (Bowfin)	p,r
Ameiurus nebulosus (Brown bullhead)	p,r
Erimyzon sucetta (Lake chubsucker)	p,r
Fundulus dispar (Starhead topminnow)	p,r
Fundulus notatus (Blackstripe topminnow)	p
Ictalurus punctatus, (Channel catfish)	p
Lepisosteus oculatus (Spotted gar)	p,r
Lepomis gibbosus (Pumpkinseed)	p,r
Lepomis gulosus (Warmouth)	p,r
Lepomis humilus (Orangepotted sunfish)	p,r
Lepomis macrochirus (Bluegill)	p,r
*Lepomis miniatus** (Redspotted sunfish)	p,r
Micropterus salmoides (Largemouth bass)	p.r
Notemigonus crysoleucas (Golden shiner)	p,r
Pomoxis nigromaculatus (Black crappie)	p,r
Pomoxis sp. (Crappie sp.)	P**

*This species is being stocked in the rare fish lake in cooperation with Trent Thomas, IDNR. ** These were individuals too small to accurately identify.

Although a number of species have not been detected, they may be present in numbers too low to detect or the methods used for detection are inadequate or both. We expect additional species to be eventually detected. Also, some of the species, particularly the darter species (*Percina* and *Etheostoma*) and Tadpole madtom (*Noturus gyrinus*) may simply be difficult to detect even in fairly high numbers. Special sampling techniques will be required for these species, possibly including the sound detection method previously described.

Spunky Bottoms, Brown County, IL

The lake at Spunky Bottoms (approx. 39^{o} 53' N, 90^{o} 35' W, Fig. 6) was another bottomland lake of the Illinois River that was drained and isolated from the Illinois River channel early in the last century. In contrast to the other project areas, Spunky Bottoms was not rehabilitated so fishes were stocked into a system of a small number of native fishes and the Common carp (*Cyprinus carpio*). The native fauna mostly included common native species (e.g., Green sunfish, *Lepomis cyanellus*, Black bullhead, *Ameiurus melas*). These species are indicative of a community of average or lesser quality. TNC expressed interest in trying to improve diversity of fish community without the radical removal of the fish fauna. In that light, fish species were stocked that we considered likely to survive in a medium quality habitat and perhaps help control the Common carp population.

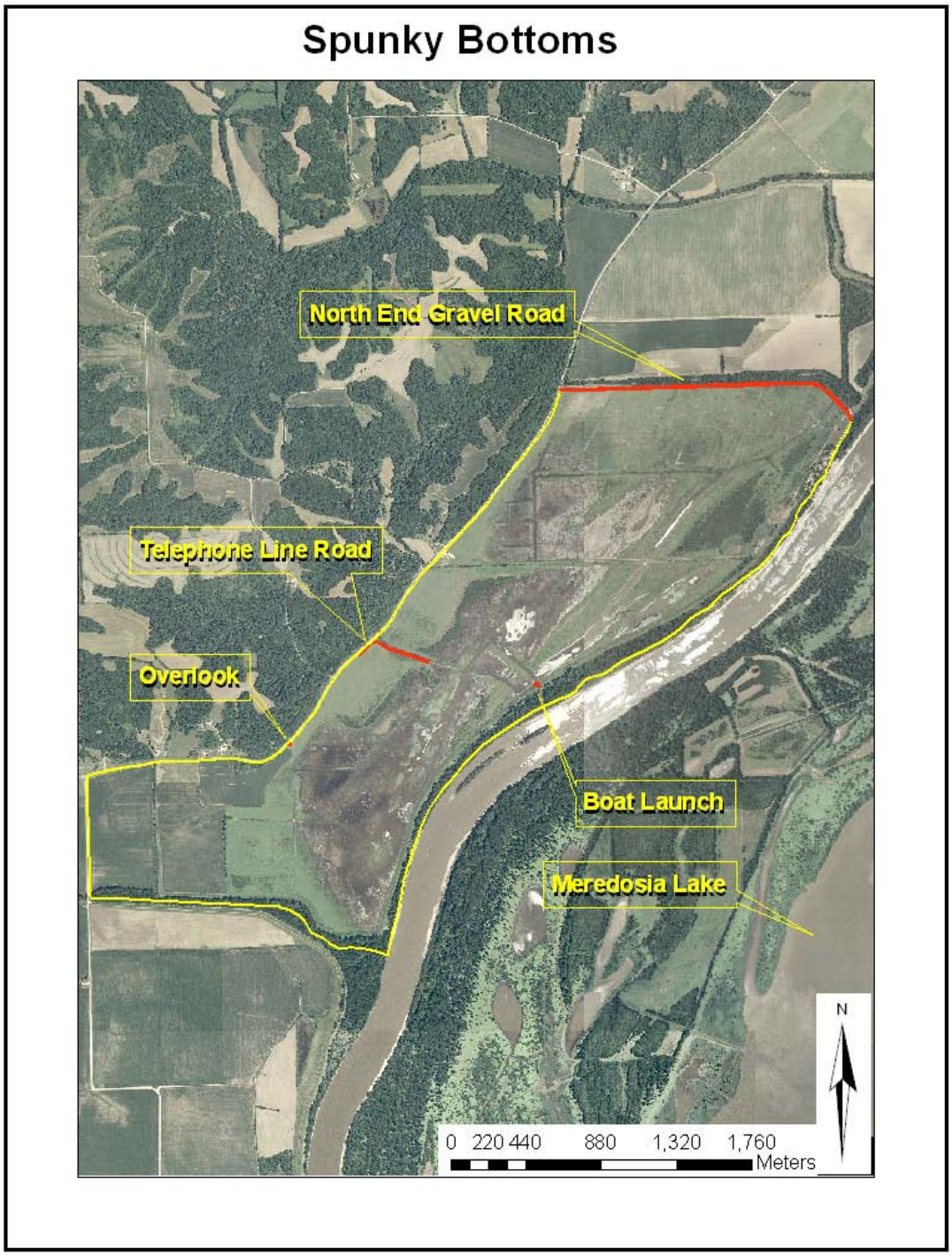

Figure 6. Map of Spunky Bottoms (enclosed by yellow line and north end gravel road), Brown Co., IL.

At the beginning of the project, the submergent aquatic vegetation was fairly limited and water turbidity was high relative to Hennepin-Hopper. Like Emiquon, the dry

summer of 2007 had a great impact on waters levels of the lake. Essentially most of the flooded fields dried out and standing water was limited to the man-made ditches. While the lake was normally about 800 to 1,000 acres, the total area was probably reduced by half or more. Unlike Thompson Lake, groundwater appears to be less important as a source of water for the lake. In turn, heavier precipitation in 2008 and 2009 greatly increased water levels. Water has returned to the field and extended to a level above normal. In 2009, the pumps were turned on to lower the levels primarily to keep the road on the north boundary above water and the riverside levee accessible. In short, the water levels have fluctuated greatly during the project.
When the fields re-flooded in early 2008, Common carp (*Cyprinus carpio*) had the opportunity to spawn and produced a sizable year class. Correlated with this was an increase in water turbidity and reduction in aquatic vegetation. In 2009, the Common carp did not appear to have another highly productive spawning event, and water clarity seemed to improve and aquatic vegetation increased.

Stocking of Spunky Bottoms

A total of 17 species were stocked into Spunky Bottoms (Table 5, Appendix 1c). With the expert knowledge of Doug Carney (IDNR) and Randy Sauer (IDNR), we were able to obtain several species in adequate numbers from the area around Lake Carlyle, Clinton County. These were Pirate perch (*Aphedoderus sayanus*), Grass pickerel (*Esox americanus*), Tadpole madtom (*Noturus gyrinus*), Golden shiner (*Notemiginus crysoleucas*). Additional Grass pickerel and Lake chubsucker (*Erimyzon sucetta*) were obtained from Crane Creek in Mason County.

The effort to collect Bowfin (*Amia calva*) in other Illinois River backwaters failed to collect that species but we did find a large number of Shortnose gars (*Lepisosteus platostomus*) that were stocked in 2009. We had thought that Spotted gar (*Lepisosteus oculatus*) would be suitable for Spunky Bottoms. But with the high turbidity and less aquatic vegetation present in 2008, the Shortnose gar was probably a better choice for stocking. We also focused more on species that would be more tolerant of these conditions such as Blackstripe topminnow, *Fundulus notatus* (rather than Starhead topminnow, *Fundulus dispar*) and Orangespotted sunfish (*Lepomis humilis*).

Early in 2007, we isolated a ditch along telephone line road (Fig. 6) by placing a 1/4” mesh net across the ditch and stocking it with Grass pickerel, Central mudminnows (*Umbra limi*), Pirate perch, Lake chubsucker, Johnny darters (*Etheostoma nigrum*), and Pumpinkseed (*Lepomis gibbosus*). However, by mid-summer, lack of precipitation caused a drastic drop in the water level and the ditch dried up. We were not able to recover stock for the ditch but examination of the net suggested that at least some individuals had escaped. Like at Emiquon, we were surprised at the extreme changes in water levels. By mid 2008, water levels had recovered and then proceeded to rise to very high levels by 2009. After this attempt, we chose to introduce stock directly into the lake in areas that had appropriate habitat for the species.

Table 5. List of species stocked and numbers stocked at Spunky Bottoms during this project.

Species		Number of Individuals
Amia calva	(Bowfin)	1
Aphredoderus sayanus	(Pirate perch)	214
Catostomus commersoni	(White sucker)	4
Erimyzon sucetta	(Lake chubsucker)	26
Esox americanus	(Grass pickerel)	71
Etheostoma gracile	(Slough darter)	6
Etheostoma nigrum	(Johnny darter)	48
Fundulus notatus	(Blackstripe topminnow)	59
Lepisosteus oculatus	(Spotted gar)	1
Lepisosteus platostomus	(Shortnose gar)	26
Lepomis gibbosus	(Pumpkinseed)	1391
Lepomis humilis	(Orangespotted gar)	347
Lepomis microlophus	(Redear sunfish)	6
Notemigonus crysoleucas	(Golden shiner)	11
Noturus gyrinus	(Tadpole madtom)	121
Percina caprodes	(Logperch)	1
Umbra limi	(Mudminnow)	26

Species were stocked primarily along the telephone pole road and at the south end at the overlook (Fig. 6). Six of the 17 stocked species were introduced in low numbers (<20) and three in relatively high numbers of more than one hundred individuals. We were able to obtain a large number (N=1364) of Pumpkinseed (*Lepomis gibbosus*) mostly from an IDNR brood pond at Banner Marsh (Fulton-Peoria Cos.).

Assessment of the Stocking of Spunky Bottoms

Some preliminary stocking began in fall of 2007 using minnow traps. The water levels had dropped significantly to the point that fields were dry and water retreated to the main ditches. Not surprising stocked species were not collected, however, a number of young-of-the-year Common carp (*Cyprinus carpio*) were caught. These carp indicated that a large spawn occurred that year and suggested that turbidity would be high in the next few years, and the aquatic plant community would be suppressed. This finding changed the emphasis of what would be stocked in 2008 and 2009. Species more tolerant of higher turbidity and less aquatic vegetation would be stocked.

As at the other sites, boat electroshocking, backpack electroshocking, visual search with dip nets, minnow traps, and minifyke nets were used to assess the lake. The backpack electroshocking, visual search with dip net, minnow trap, and minifyke net methods were utilized in the areas where the stock were released. Boat shocking over a large portion of the lake occurred in the fall of 2008 and 2009. In addition, we were given the list of species collected by boat electroshocking by the INHS Havana field station crew. They sample Spunky Bottoms annually in the fall.

Four of the 17 species or 29% of the species were detected in the 2008 and 2009 surveys combined (Table 6). Three species (18% of the species stocked) were detected as having reproduced in the lake. Although the percentages were not as good as at Emiquon, the lower detection rate at Spunky may also be due to the fact that much of the stocking did not occur until 2009 (Appendix 1c). With later stocking there would be little time to for spawning to take place. Also, the very high water levels in 2009 have diluted the numbers making them harder to detect. We feel that higher number of the stocked species probably have survived and will reproduce, but it will take several years before they reach detection levels.

Table 6. List of stocked species detected at Spunky Bottoms 2008-2009. p = present, r = reproduction evident.

Species	Status
Esox americanus (Grass Pickerel)*	p,r
Fundulus notatus (Blackstripe topminnow)	p
Lepomis gibbosus (Pumpkinseed)	p,r
Lepomis humilus (Orangepotted sunfish)	p,r

*T. Hobson (pers. comm.) described netting and then losing a small slender fish through the mesh of the net. His description applies more to the Grass pickerel than the Shortnose gar although we cannot be certain.

The orangespotted sunfish (*Lepomis humilis*) reproduced as we expected them to. Because of the high turbidity and a paucity of aquatic vegetation, we were less certain that the Pumpkinseed (*Lepomis gibbosus*) would become established. It appears to be reproducing and this suggests that this species can be stocked into lakes with less vegetation and high turbidity.

Overall, we tentatively consider the stocking of Spunky Bottoms to be successful but additional monitoring is required to see if the four species detected continue to persist. In addition, if species not detected now become more numerous, continued monitoring will reveal their presence. We anticipate that the Shortnose gar (*Lepisosteus oculatus*) will become established in the lake.

Monitoring should continue of the lake conditions (i.e., turbidity and aquatic vegetation) and the carp population. TNC and we are interested in if a more diversity community may result in a more stable community. Part of our reason to stock the Shortnose gar (*Lepisosteus oculatus*) and Grass pickerel (*Esox americanus*) was to see if carp populations could be reduced by these species. Carp control would result in a more stable and diverse community. Common carp (*Cyprinus carpio*) is the single most important threat to these restoration projects in our opinion. Also note that although the lake is isolated from the Illinois River, a single large silver carp was observed in the lake in fall of 2009. It is unknown how this species entered the lake and it is unknown what effects the Asian carps might have on the lake

Spunky Bottoms differs from the other two lakes in that it has not undergone rehabilitation (removal of fishes by a toxicant, rotenone). Pre-stocking, it had a relatively un-diverse fish biota due to long isolation and restricted habitat (mostly ditches). In 2009, our survey and the one by INHS Brighton lab found thirteen species of native species in

the lake. The presence of just three reproducing species greatly increased the fish diversity by 33%. These three species and possibly more may have a positive impact on the entire community and perhaps a negative impact on the Common carp.

CONCLUSIONS AND RECOMMENDATIONS

- The goal of establishing four to six species at each of the three study sites was achieved and exceeded at Emiquon, possibly met at Spunky Bottoms but additional monitoring is needed, not met at Hennepin-Hopper as the system collapsed under the weight of the expanding carp population before species could be fully stocked.
- A total of 35 species were stocked and totaled 1,711,055 individuals. Most of these were stocked at Emiquon (1,704,364).
- The use of isolated ponds and ditches without predators should be used to establish large numbers of young for direct stocking into lakes.
- All effort must be made to control non-native fish species especially the Common carp (*Cyprinus carpio*). Removal of carp before stocking is recommended as well as the use of predators to suppress carp populations. Research into carp management is recommended.
- The creation of high density fish predator populations may also have negative survival effects on other stocked fish until the appropriate habitat develops.
- Emiquon should be a model for the restocking of Hennepin-Hopper and other lakes. For small-bodied species only available in limited numbers (<100), isolated ditches or adjacent ponds should be used to establish large numbers of young for direct stocking. If possible, these ditches should be allowed to be subsumed into the lake as water levels rise, thus directly stocking the lake.
- We recommend that other areas in Illinois and upper Midwest be studied for suitability for establishment of native fish communities.
- Future efforts at other lakes should be prepared for the wide variation of water levels, changes in aquatic vegetation, etc. that can occur within a year's time.
- Future efforts should try to stock a mix of species that will include wide taxonomic representation, represent different trophic levels, and use a variety of habitats.

ACKNOWLEDGMENTS

Many individuals with our partners the Illinois Department of Natural Resources, The Nature Conservancy, and The Weltands Initiative made this project successful. In particular, thanks go to Rob Hilsabeck, Wayne Herndon, Doug Carney, Trent Thomas, Gary Lutterbie, Tharran Hobson, Sally McClure, and Gary Sullivan.

SPECIES ACCOUNTS

This section provides information on most of the species that were stocked in the lakes. We omitted some accounts for some of the stocked species such as the slenderhead darter (*Percina phoxocephala*) because these species were stocked incidentally in small

numbers. Or for the Largemouth bass (*Micropterus salmoides*) and Bluegill (*Lepomis macrochirus*), these species are easily stocked and an enormous literature already exists for them. We hope that these accounts will help future biologists and restoration managers to make better decisions when considering what species to stock into these types of lakes.

Note that we have included the trophic level value for each species. This value is available on Fishbase (http://www.fishbase.us/search_region.php?region=americas). These values may be helpful in when attempting to establish a sustainable food chain and web. Knowing the diet, spawning, and habitat requirements will help in deciding the most appropriate species for stocking and the sequence at which they are stocked. A value of 2 or less indicates that a species feeds very low on the food chain mostly on detritus and plant materials. Those species with a value of 4 or higher feed near to or at the top of the food chain. Their diet will mostly be other fishes. Those species with values in the middle generally eat invertebrates.

In addition to Fishbase, we referred to common sources of information in the literature and our professional experience. These sources include Becker (1983), Craig (1898), Forbes and Richardson (1920), and Smith (1979). For size ranges of each stocked species see Appendix 2.

Brown Bullhead- *Ameiurus nebulosus*

Diet: This species has a diet that consists of a wide variety of benthic prey items including insect larvae (primarily chironomids), fingernail clams, snails, crayfish, annelids and other fishes.

Habitat: This species is found in lakes, ponds, and slow moving creeks and rivers. It is usually associated with rooted aquatic vegetation and soft substrates.

Trophic Level and Community Role: 3.3

Spawning: This species spawns in May. The nests are constructed in the substrate, and both male and female are involved in nest construction and defense.

Number stocked: 166

Stocking sources: Spring Lake (Mason Co.), Anderson Lake, Rice Lake (Fulton Co.), Mickelsons Landing Mississippi River, (Carroll Co.)

Stocking sites: Emiquon

Assessment: The species appears to be reproducing in Emiquon

Emiquon

A total of 166 individuals was stocked over the three-year period. In 2007, 23 individuals were stocked into the office pond. Then 12 were removed in 2008-09 and stocked into Thompson Lake. An additional 131 were stocked into the main lake body in 2008-09. In 2008, no Brown bullheads were detected in either the pond or Thompson Lake. In 2009, three individuals where caught in Thompson Lake, including one juvenile. We expect that increasing numbers will be found in later surveys. The pond did eventually produce a small number for stocking the main lake. However, as more were caught in the wild, the use of brood ponds needs more research. The pond is small and contains no fish predators. Habitat in the pond appeared suitable for this species. Trent Thomas (IDNR, pers. comm.) had a similar experience when he had stocked a similar pond.

Comments: The Brown Bullhead is less common than the other two bullhead species in the state, and probably is less widely distributed historically. Habitat conditions are most ideal at Emiquon at the current time. Note that this bullhead had been stocked (50 individuals) at Hennepin-Hopper before this project and an estimated 200 individuals were recently observed in a draw down of the lake. Some of these individuals will be returned to the lake after it is rehabilitated in 2010. Trap nets and boat shocking are the best methods for capturing this species. Because a high number of Yellow bullheads (*Ameiurus natalis*) and Black bullheads (*Ameiurus melas*) already occur at Spunky Bottoms, a third bullhead species may not be able to compete in this lake.

Bowfin- *Amia calva*

Diet: This species is a voracious feeder. Prefers to eat other fish, but very opportunistic and will also eat crayfish, insects, and frogs.

Habitat: This species is found in well-vegetated lakes, rivers, and swampy areas. It is a facilitative air-breather that allows this species to survive in water with high temperatures and low levels of oxygen.

Trophic level and community role: 3.8

Spawning: This species is spawns from April to May. Nests are constructed amongst the vegetation and are guarded by the parents.

Number stocked: 43

Stocking sources: Rice and Big lakes (Fulton Co.), Mickelsons Landing Mississippi River, (Carroll Co.), Red Oak Ditch and Crane Creek (Mason Co.)

Stocking sites: Emiquon, Spunky Bottoms

Assessment: The Bowfin (*Amia calva*) has been established at Emiquon and not at Spunky Bottoms.

Emiquon

A total of 42 individuals was stocked into the ditches at Emiquon (Fig. 5) in May of 2007. Three individuals were captured in August of 2008 in minnow traps water just south of pumphouse road. All three were approximately 350mm in length, and two were preserved and put into the INHS fish collection as their capture resulted in mortality from asphyxiation. These individuals are likely the offspring of the fish stocked in 2007. In October of 2008, a shock-boat survey found numerous Bowfin of various sizes in all areas of the main lake body. Several young of the year were also found. There appears to be a strong, reproducing population of Bowfin at Emiquon. Conditions there are excellent for this species. The lake is clear with lots of submerged vegetation, and the lake is filled with small centrarchid sunfishes for forage.

Spunky Bottoms

One individual was stocked in May 2008 near the overlook (Fig. 6). Conditions are ideal for this species, but surveys have not yet found any bowfin because of the low number stocked. At least 20 additional individuals should be stocked at Spunky Bottoms if Emiquon is a reliable guide.

Comments

The Bowfin is the only living member of a relatively ancient order of fishes. Although still relatively common in the state, it was probably much more common historically. This is likely due to the fact that there are fewer clear, well-vegetated, backwater lakes than previously existed. The Bowfin was easily captured by boat electroshocking and traps.

Stocking efforts have been successful at Emiquon due to the ideal conditions there. We've shown that strong populations can arise from a just a few brood adults, given that the site has lots of vegetation and strong populations of forage fish. The Bowfin is also a very hardy species, and could potentially survive any unforeseen disturbances to the lake, particularly those involving low oxygen levels. Bowfin will also prey on small Common Carp, helping to deter any establishment of this invasive species. For these reasons, the Bowfin is an excellent candidate for future stocking efforts at both Spunky Bottoms and Hennepin-Hopper.

We noted that three small Bowfin were asphyxiated in minnow traps that were placed in shallow areas of Thompson Lake. These traps were totally underwater and left out over night. Obviously, the dissolved oxygen had dropped to very low levels and the Bowfin had no access to atmospheric oxygen. This unfortunate event does demonstrate that biological oxygen demand can be quite high in the shallow areas and will affect the behavior of the fishes there.

Pirate Perch- ***Aphredoderus sayanus***

Diet: This species consumes primarily insects including dipteran and odonate larvae, amphipods, and glass shrimp. Occasionally found to eat cladocerans, and rarely small fish including their own young.

Habitat: This species is commonly found in slow moving streams, rivers, lakes, and sloughs. In Illinois, it is probably most common in streams. Associated with dense vegetation and soft substrates. Its habits suggest that it is not an active species that may be difficult to detect by passive traps. Its preference for hiding in dense vegetation also makes it less vulnerable to active sampling methods.

Trophic level and community role: 3.1

Spawning: Pirate Perch spawns in large root masses and vegetation. The unusual placement of the urogential pore (near the head) allows this species to get deep into the root mass to both lay and then fertilize the eggs. Males then guard the nest. However, in areas where underwater root masses are not common, it is unknown exactly how spawning occurs. Spawning takes place in late spring to early summer.

Number stocked: 356

Stocking sources: Crane Creek, Fish Creek (Mason Co.), Beaver Creek (Kankakee Co.), Red Oak Ditch (Mason Co.), Silver Creek (Bond/Clinton Co.), Beaver Creek (Clinton Co.), Central Ditch, McKee Creek (Iroquois Co.)

Stocking sites: Emiquon, Hennepin-Hopper, Spunky Bottoms

Assessment: This species has not been detected at any of the stocking sites.

Emiquon

A total of 117 Pirate perch was stocked at Emiquon, and none have been sampled since. Fifty-nine Pirate perch were stocked in to the main lake at Emiquon in 2007 and 2008; 58 were stocked into ditch KK. Ditch KK had few predators and plenty of forage for pirate perch, so we believed that there was a good possibility that a population exists in and around the ditch (the ditch has been subsumed into the lake). None have yet been found in any surveys, and their status remains unknown. The high amount of aquatic vegetation now in the lake suggests the species will be established, but the size of the lake will make detection difficult.

Hennepin-Hopper

A total of 23 individuals was stocked into the brood ditch (Fig. 3), and 2 into the area near the south seeps. To date, none have been recovered. It is unlikely that any Pirate perch remain due to the little aquatic vegetation and high density of predators in the lake. The species should be considered for stocking after the lake is rehabilitated.

Spunky Bottoms

A total of 214 Pirate perch was stocked into Spunky Bottoms along telephone line road (Fig. 6), and none have been found in any survey. A lot of good habitat for the species appears to exist. It may be avoiding detection through its secretive habits or by dilution caused by rising lake levels. Of course, it may not have survived in the lake.

Comments: The Pirate perch is the only member of the family Aphredoderidae. The breeding behavior and unusual placement of the urogenital opening make it a species of great interest to ichthyologists. So far, assessment methods appear to be ineffective. The methods used (backpack shocker and minnow seine primarily) were effective in collecting the individuals, and it stands to reason that they should work well in assessment. Electro-shock boat should also be an effective method. Its habits suggest that it is not an active species and may be difficult to detect by passive traps. Its preference for hiding in dense vegetation also makes it less vulnerable to active sampling methods. We suspect that populations will need to be very high before they can be detected by these methods. Sampling for the species at Emiquon and Spunky Bottoms should continue.

Lake Chubsucker- *Erimyzon sucetta*

Diet: The diet consists of vegetable matter, zooplankton, mollusks, and chironomid larvae.

Habitat: This species is typically associated with well-vegetated lakes over various bottom types. Sometimes found in streams.

Trophic level and community role: 3.1

Spawning: Spawns from late April through May.

Number stocked: 317

Stocking sources: Red Oak Ditch (Mason Co.), Allerton Pond, Central Ditch (Mason Co.), McKee Creek (Iroquois Co.)

Stocking sites: Emiquon, Spunky Bottoms

Assessment: The species appears established in Emiquon and not detected at Spunky Bottoms.

Emiquon

A total of 291 fish was stocked into Thompson Lake over the three-year period. Most were stocked along pumphouse road and 53 were placed into ditch KK (Fig. 5). In October, 2007 14 individuals were recaptured and moved to a ditch on the south end of Thompson Lake and 29 were placed in the TNC back office pond. Unlike the pond at Allerton Park, the TNC back office pond only produced a few when we used seines and

trap nets. We are unable to determine why the species failed to reproduce at that pond as expected.

One young of the year chubsucker was spotted during a snorkel survey in July of 2008 (N. Michaels, INHS, pers. comm.). A photo was taken for species confirmation. The boat shock survey in October of 2008 found one adult chubsucker. In 2009 an additional seven individuals of various size and age were found. The species appears to be present at Emiquon, but not in very large numbers. There appears to be reproduction, but it is unknown how successfully. The habitat is ideal for this species, but there are many predators and high water has diluted the population. More monitoring will be required to see if the population is firmly established and if additional stocking effort will be needed.

Spunky Bottoms

A total of 26 Lake chubsuckers was stocked into the ditch along telephone line road at Spunky Bottoms. Most were stocked in 2007 and one individual in 2009. So far, none have been recaptured and the status of the population is unknown. Lack of detection may be due to the low stocking rate and dilution by high water levels. The habitat appears unstable (changing turbidity and vegetation) and may limit success of the species there. More stocking effort should be made if the habitat stabilizes.

Comments: At Emiquon, we consider the stocking likely to succeed but at Spunky Bottoms the conditions may not be suitable. We suggest that this species be stocked into Hennepin-Hopper after the rehabilitation in 2010.

Grass Pickerel- *Esox americanus*

Diet: Juveniles eat primarily invertebrates, but adults are nearly entirely piscivorous.

Habitat: This species is found in lakes, swamps, and slow moving streams. Associated with dense vegetation and clear water.

Trophic Level and Community Role: 3.7

Spawning: This species spawns in the spring, relatively earlier than other fish species. Spawning takes place in dense vegetation beds, and can be done in somewhat shallow waters.

Number stocked: 238

Stocking sources: Crane Creek (Mason Co.), Red Oak Ditch (Mason Co.), Beaver Creek (Clinton Co.), Central Ditch, Fish Creek (Mason Co.)

Stocking sites: Emiquon, Hennepin-Hopper, Spunky Bottoms

Assessment: The species has only been collected at Spunky Bottoms.

Emiquon

The majority of Grass pickerel (N=156) stocked into Emiquon were placed into ditches and south of pumphouse road. No survey of the main lake body or the ditches has recaptured any Grass pickerel. The current status of this species at Emiquon remains unknown. The current habitat is ideal, and populations of prey fishes are strong. Most of the individuals stocked were large enough to escape predation by Bowfin and Largemouth bass so there is a good chance that a population still exists. Their preference for heavy vegetation and dilution by high water levels make their assessment more difficult. We expect them to become established but higher population levels will be needed to detect their presence. Monitoring should continue especially in shallow areas with vegetation. Additional stocking may be considered.

Hennepin-Hopper

A total of 11 Grass pickerel was stocked into the brood ditch at the north end of Hennepin-Hopper in 2007 before it was isolated and rotenoned in 2008. It was possible that a few individuals escaped from the brood ditch and entered into the main lake. No individuals were seen in the ditch after it was rotenoned. This species is a good candidate for stocking after the rehabilitation to take place in 2010.

Spunky Bottoms

A total of 71 Grass pickerel was stocked into Spunky Bottoms over three years into both the area below the overlook parking area and along the telephone line road. The greatest number, 49, were stocked in 2009. In September of 2008, one individual (207mm in total length) was found in the mid-telephone road area during a boat electroshocking survey. Our fall 2009 sampling did not turn up any individuals. However, T. Hobson reported seeing a small individual during the INHS Brighton Field station sampling in 2009. The habitat looks suitable and we expect the species to become established. Monitoring should continue especially in shallow areas with vegetation. Additional stocking may be considered.

Comments: Although still common, this species was probably more common than it is now, and it is a desired species in all three lakes. Given the issue of maintaining low Common carp (*Cyprinus carpio*) populations in these lakes, the stocking of other species that will suppress carp should be a priority. Richardson (1913) long ago suggested that Grass pickerel might be predators on young carp. That view would make this species an even more desirable stocking candidate. More stocking and sampling effort will be required to address the success of this species.

While seining was a somewhat effective collection method, backpack shocking proved to be much more effective as it is a more efficient method in densely vegetated areas. The barge electroshocker used in Crane Creek (Mason Co.) was very effective but also had a higher rate of mortality and stress on the species.

Mud Darter- *Etheostoma asprigene*

Diet: This species consumes primarily aquatic insect larvae, including chironomids.

Habitat: This species is found in slow moving riffles of streams and rivers, also found in some lakes. It is associated with a variety of substrates from gravel to silt.

Trophic Level and Community Role: 3.2

Spawning: This species spawns from March to May and occurs over vegetation. Eggs do not necessarily need to adhere to the underside of rocks as in other darter species.

Number stocked: 55

Stocking sources: Fish Creek (Mason Co.), Rice Lake (Duck Island, Fulton Co.)

Stocking sites: Emiquon

Assessment: The species has not been detected at Emiquon.

Emiquon

A total of 55 Mud darters was stocked at Thompson Lake. Of these, 50 were stocked at the quarry in 2007 (Fig. 5). Another 5 Mud Darters were stocked near the pumphouse road in October of 2008. None have been found in any survey, and it is possible that it was not stocked in sufficient numbers. This species is a good candidate for future stocking at Emiquon as it prefers this type of habitat.

Comments: This species could be an excellent candidate for future stocking efforts at all three sites. Although we have not yet had any indication of success, the habitat at the sites is more ideal for this species than any other darter except the Slough darter (*Etheostoma gracile*). Darters in Illinois are a quality source of diversity in fish populations, and an effort should be made to include darters in these restorations. Finding large numbers for direct stocking may be difficult so we suggest that brood stock be started in isolated ponds or ditches. Because the species is drab, small and benthic, backpack shocking and seining are probably the best methods of capture. In general, small benthic species are more difficult to sample unless they are in shallow areas and in high numbers.

Johnny Darter- *Etheostoma nigrum*

Diet: This species feeds on primarily chironomid larve as well as other insects.

Habitat: This species is most commonly found in pools of streams and rivers over sand, gravel, or rocky bottoms but also can be found in pools with silt bottoms (M. Retzer, pers. obvs.). The species seems more tolerant of poor water quality than other darter species. When found in lakes, this species is associated with sand bottoms.

Trophic Level and Community Role: 3.2

Spawning: Spawning in Illinois takes place in May. Like some other darter species, eggs are attached to the underside of rocks or other substrates, and are guarded by males.

Number stocked: 228

Stocking sources: Crane Creek/Red Oak Ditch (Mason Co.), McKee Creek (Brown Co.), Kelly Creek (Livingston Co.).

Stocking sites: Emiquon, Hennepin-Hopper, Spunky Bottoms

Assessment: The species has not been detected at any of the stocking sites.

Emiquon

A total of 73 Johnny darters was stocked along pumphouse road in 2007 and 2008. All fish were stocked onto the gravel bottom on the original road bed. As of yet, none have been recaptured. It is difficult to say if this artificial habitat will be suitable for this species. This species will likely have to be stocked in greater numbers to achieve success. As this species requires gravel or sand bottom to thrive and reproduce, all future stocking attempts should focus on the gravel near pumphouse road or by the old quarry. See comments below.

Hennepin-Hopper

One individual was stocked into the brood ditch in 2007. Following the rotenone treatment, and due to the high density of large predatory fish, it is unlikely that the one individual remains. The possibility of future stocking can be assessed after the lake is rehabilitated in 2010. There are areas with firm substrates that could be suitable for the species.

Spunky Bottoms

A total of 154 Johnny Darters was stocked into Spunky Bottoms over the three-year period. However, most were not stocked until late in 2009. Until that time, assessment activities failed to find any individuals using boat electroshocking, visual with dipnets, and trap nets. With the rising water levels and small numbers stocked, we were not surprised that none were found.

The 109 individuals stocked in late 2009 were placed in the recently flooded north side. The area is a mosaic of different substrates including rock and gravel. This area

should be sampled over the next few years to see if a sustainable population has been established. Also late in 2009, we found a population of Orangespotted sunfish (*Lepomis humilis*) on the east side of the lake (not a stocked area). The substrate here seems more appropriate for the Johnny darter. Because, Orangepotted sunfish and Johnny darters often occur together, this could be an area for additional stocking.

Comments: This species is probably more common on gravel and mud substrates of creeks and small streams although Forbes and Richardson (1920) noted that the species could be found on mud substrates and in lakes. The Mud darter was probably more common in these lakes, however, this darter was more difficult to obtain. Darters add an important element of diversity and occupy a benthic habitat that less used by other fish species. Effort should be made to further stock them in the lakes.

Both seining and shocking proved to be relatively effective method of collecting the Johnny darter. Assessing this species is more of a problem in that it is a benthic species likely to move only short distances. And it has been noted to occur in deep areas of lakes, another difficult area to sample. This makes the species less vulnerable to capture by boat electroshocking and stationary traps. If it occurs in aquatic vegetation, it will be less susceptible to detection. Hence, additional effort must be made to detect the species and the species will need to be present in high numbers. In Emiquon and Spunky Bottoms, monitoring should continue for another few years.

Starhead Topminnow- *Fundulus dispar*

Diet: This species consumes terrestrial and aquatic insects, snails, zooplankton, and some algae.

Habitat: This species is known to inhabit glacial lakes, oxbow and backwater lakes, swamps, and quiet pools of streams, and is almost always found in association with dense aquatic vegetation. It prefers clear water with soft mud or detritus bottom.

Trophic level and community role: 3.1

Spawning: This species spawns from late spring to early summer in dense beds of vegetation. Eggs are attached to submersed or bottom vegetation.

Number stocked: 9,370

Stocking sources: Allerton Pond, Piatt County, IL (an IDNR brood pond, original stock from Crane Creek, Mason County), TNC Emiquon brood pond, and Iroquois Conservation Area (an IDNR brood pond, original stock from Beaver Creek, Iroquois County). Fish were collected by use of minnow seine and backpack shocker. The majority of topminnows stocked (>4,000) were from the TNC office brood pond. These were originally captured from Crane Creek, Mason County. Fish were easily removed from the brood pond with minnow seines, and given the high fecundity of this species, use of some sort of brood pond or isolated ditch is recommended.

Stocking sites: Emiquon, Hennepin-Hopper.

Assessment: The species has been established in Thompson/Flag lakes and the rare fish refuge at Emiquon (Fig. 5). The species has not been found at Hennepin-Hopper. It is not expected to become established now that the lake is being rehabilitated to remove Common Carp (*Cyprinus carpio*)

Emiquon

Approximately 300 topminnows was seined from Emiquon ditch KK in October of 2007 (Fig. 5). Only 49 topminnows were stocked into ditch KK in May of 2007, so we know Starhead topminnows will breed in ditches. Most of the 300 topminnows were translocated to the TNC office brood pond and a small number were directly stocked into the SW portion of Thompson Lake. In 2008 and 2009, >4,000 topminnows were moved from the TNC office brood pond to the western side of Thompson Lake (Fig. 5). Topminnows have been seen and collected with a dipnet at the southern end of Thompson Lake. In 2009, Starhead topminnows (*Fundulus dispar*) were observed in the flooded fields just north of ditch KK. The individuals likely came from ditch KK when the lake subsumed the ditch. The 120 individuals stocked into the rare fish refuge survived and have become very common.

Hennepin-Hopper

Approximately 70 individuals were stocked along the east shore especially in the seep area along the southeast shore. Visual and dipnet search by boat and on foot revealed no Starhead topminnows. Visual searches were made difficult because of the high turbidity of the lake caused by an upsurge of Common Carp (*Cyprinus carpio*).

Comments: The Starhead topminnow (*Fundulus dispar*) is currently listed as threatened by the Illinois Department of Natural Resources. This topminnow occupies the upper water column and is known to be a preferred prey of the spotted gar (also stocked in Emiquon). In predator free ponds, the species flourishes and produces enough young for stocking within one year. If clear water and vegetation can be maintained, the species is likely to survive in restored lake communities. We noted that Mosquitofish (*Gambusia affinis*) appeared to suppress Starhead topminnow reproduction in ditch KK and competed equally well in the TNC office brood pond. Recent literature suggests that the Mosquitofish negatively effects other species (Laha and Mattingly, 2007). Effort should be made to limit or eliminate *Gambusia* in brood ponds and restoration sites.

We have had good success in assessing topminnows by seine and visual/dipnet sampling. Minnow traps were less successful than the methods previously mentioned. The species seems less susceptible to electroshocking methods. Topminnows were easily collected with seines from the brooding areas.

Note that several thousands were placed along the west shore of Thompson Lake from just north of the boat launch to the pumphouse road (Fig. 5). Searches have not revealed topminnows in that area. This suggests that they either moved to the south end or did not survive. Although the area looked suitable for stocking, rapid changes to the

lake may have made the area unsuitable for the species. This further suggests that if possible, several different areas be stocked to help insure the species will find at least one area with suitable habitat.

Blackstripe Topminnow- *Fundulus notatus*

Diet: This species has a diet similar to that of the Starhead Topminnow, the diet consists mainly of aquatic insects and zooplankton, with some snail and algae.

Habitat: This species prefers quiet surface waters in lakes, ponds, streams, swamps, and rivers and is usually associated with vegetation.

Trophic Level and Community Role: 3.1

Spawning: This species spawns from late spring to summer. Eggs are usually adhered to vegetation, but in the absence of that, will stick to detritus and leaf litter.

Number stocked: 562

Stocking sources: McKee Creek (Brown Co.), Central Ditch, Crane Creek, Fish Creek (Mason Co.), Hennepin Canal, Kelly Creek (Ford Co.), Mud Creek (Livingston Co.), Vermillion North Fork, Mauvaise Terre Creek (Scott Co.)

Stocking sites: Emiquon, Spunky Bottoms

Assessment: The species has been detected at Emiquon and Spunky Bottoms in very small numbers.

Emiquon

A total of 498 individuals was stocked in Emiquon. All but one was stocked in 2007 and 2008. In 2007, 236 individuals were stocked into ditches. In 2008, 261 were added along pumphouse road (Fig. 5). A number of individuals were observed in that area in 2008 but none in 2009. It can be difficult to distinguish between large Mosquitofish (*Gambusia affinis*) and Blackstripe Topminnows (the Starhead topminnow, *Fundulus dispar* is quite distinct from the other two species) during visual surveys, so this species may still be present but in very low numbers. An unknown number of individuals were also seen in visual surveys of ditch DD (Fig. 5). No topminnows have been stocked into ditch DD so those individuals migrated over from either the main lake body or another ditch.

Spunky Bottoms

A total of 63 individuals was stocked into Spunky Bottoms. All but four were placed along the telephone line road. A survey in September 2008 found one young of the year Blackstripe topminnows near the mid-telephone line road area. Another individual was observed below the overlook, well south of the primary stocking area. These sightings are

promising because few stocked species have so far been seen in Spunky. We were expecting to see higher numbers by the end of 2009.

Comments: The Blackstripe topminnow (*Fundulus notatus*) is similar in many ways to the Starhead topminnow (*Fundulus dispar*). This species is not considered threatened, but is rather common around the state. It is a very fecund species and some measure of stocking success has been seen despite high piscivore populations. Based on results so far more stocking effort will likely be required at Emiquon and Spunky Bottoms. Both seining and shocking proved to be effective methods of capture.

Channel Catfish- *Ictalurus punctatus*

Diet: This species is primarily a benthic feeder, it will eat aquatic insects, clams, snails, and crayfish. Larger individuals will feed on some fish.

Habitat: This species is most commonly found in medium to large rivers, but has been stocked successfully in lakes, ponds, and reservoirs.

Trophic Level and Community Role: 3.4

Spawning: This species spawns from May to July. Like other catfish species, a nest is constructed and guarded but, unlike other catfish, the female does not participate in nest construction or defense.

Number stocked: 106

Stocking sources: Illinois River, river mile 133, Big/Rice lakes (Fulton Co.), Hennepin Hopper (Putman Co.), Banner Marsh (Fulton-Peoria Cos.)

Stocking sites: Emiquon

Assessment: Status is uncertain for Emiquon.

Emiquon

A total of 106 individuals was stocked at Emiquon. Of these 103 were stocked in various ditches in 2007. Another 3 individuals were stocked in the main lake body at the boat ramp in May of 2008. Only one individual has been found. This individual was young-of-the-year (60 mm total length) and caught in a minnow trap. The fishery assessment was that predation has been very high on the young (Hilsabeck, 2009, IDNR Lake Management Status Report). Additional nonvulnerable size stocking will probably be required to establish the species with certainty.

Comments: The Channel catfish is a popular game species and could help to improve public opinion of the Emiquon project. Although the species may not become common in the lake, it could be another predator on the Common carp (*Cyprinus carpio*).

Brook silverside – *Labidesthes sicculus*

Diet: This species feeds on small insects and zooplankton.

Habitat: This species is a topwater species that has been described as more common in lakes and sloughs with less vegetation.

Trophic Level and Community Role: 3.0

Spawning: The species lives only one year and spawns only one season. Spawning occurs in large schools over shallow water. The eggs are broadcast.

Number: 600

Stocking source: Powerton Power cooling Lake (Tazewell Co.)

Stocking sites: Emiquon

Assessment: The species has not been detected at Emiquon since 2007.

Emiquon

All 600 individuals was stocked at the boat ramp of Thompson Lake in 2007. Reproduction was observed in the form of large schools of small silversides in the late summer of 2007 along the flooded pump house road submerged gravel. Although the species may be found naturally in backwater lakes, the species was also stocked as a forage species for the Spotted gar (*Lepisosteus oculatus*). The species appears to prefer lakes with large open pelagic areas and less aquatic vegetation. These habitat conditions did not develop at Emiquon until late in 2008.

Comments: As just stated, the species was stocked as a forage species for the Spotted gar (*Lepisosteus oculatus*). The gar is known to feed on topminnows (*Fundulus*), another group of topwater species. The silversides would provide some forage for the gar and help reduce predatory pressure on the topminnows being stocked. The species has not been detected at Emiquon possibly due to the high predatory pressures in the lake and lack of pelagic habitat until late in 2008. More favorable habitat now exists at Emiquon and future stockings may be more successful here and at Spunky Bottoms.

Spotted Gar- *Lepisosteus oculatus*

Diet: Juveniles will feed primarily on insects and plankton, but the diet will rapidly shift towards other fishes. The species is considered to be a voracious piscivore. The diet of adults consists primarily of fishes, with some aquatic insects.

Habitat: This species is abundant in clear, heavily vegetated backwaters and oxbow lakes. Also it is found in creeks, small to large rivers, and swamps.

Trophic Level and Community Role: 4.0

Spawning: This species spawns in the spring, relatively earlier than other fishes. Spawning has been observed over dead vegetation and algal mats in backwater areas.

Number stocked: 57

Stocking sources: Big Lake (Fulton Co.), Spring Lake Ditch overflow (Mason Co.), The Glades (Jersey Co.)

Stocking sites: Emiquon, Spunky Bottoms

Assessment: Established in Emiquon with some evidence of spawning. Not likely to become established at Spunky Bottoms without further stocking.

Emiquon

A total of 56 Spotted gars was stocked in the ditches and the main lake by the boat ramp in 2007 and 2008. A number of adult individuals and 1 juvenile were seen in a visual survey of ditch DD (Fig. 5) in August 2008, and one juvenile (270 mm TL) was captured in 2009. INHS Havana field station staff (N. Michaels, pers. comm.) captured three large adults in 2009. Although the individuals that were stocked were adults, they did not appear to wander throughout the lake but remained in the northern half where they were stocked.

Spunky Bottoms

One individual was stocked at Spunky Bottoms. Without further stocking, a population will not be established. Given the tendency of the lake to be turbid, the shortnose gar (*Lepisosteus platostomus*) is probably better for this site.

Comments: The Spotted Gar is another species that is probably not as widely distributed as it had been in the past, and was likely very common in these types of backwater environments. The vegetation at Emiquon is thick, providing excellent hideouts for this ambush predator. Given the small number stocked into this large lake, we are not surprised that few have been captured but the presence of juveniles suggests that a population is being established. Emiquon could be a source of brood stock if the species becomes common. Topminnows have been noted as a forage fish for the Spotted gar. We expect that the Spotted gar will benefit from this food source as the Starhead topminnow (*Fundulus dispar*) population increases.

Longnose Gar- *Lepisosteus osseus*

Diet: The food preferences are nearly identical to that of the Spotted Gar. Young will feed on insects and plankton, and will rapidly shift towards piscivory. The diet of adults will consist almost entirely of fish.

Habitat: This species is common in lakes, streams, and rivers. Juveniles will prefer weedy shoreline habitat, while the adults are typically found in quiet pools.

Trophic Level and Community Role: 4.2

Spawning: Reproductive behavior of this species is similar to that of the Spotted Gar. This species spawns in spring, and eggs are deposited on vegetation.

Number stocked: 14

Stocking sources: Big Lake (Fulton Co.), Illinois River, river mile 134.

Stocking sites: Emiquon

Assessment: The species has not been detected at Emiquon.

Emiquon

A total of 14 Longnose gar was stocked at Emiquon. Of these, 13 individuals were stocked into the main lake body in 2008, and 1 has been stocked into ditch KK. So far, no survey has revealed any in either the main lake or the ditches. It is likely that this species has not been stocked in sufficient numbers, although the habitat is ideal and prey fish are plentiful.

Comments: One reason that few of these gars were collected from sites along the Illinois River is that the species is more common in the small rivers. Although it occurs in and along the Illinois River, it is much less common than the other two species of gar that occur in Illinois.

Shortnose gar- *Lepisosteus platostomus*

Diet: The food preferences are apparently unknown and presumed similar to that of the other gar species.

Habitat: This species prefers large rivers and bottomland lakes. It is more tolerant of turbid conditions than the Spotted gar (*Lepisosteus oculatus*).

Trophic Level and Community Role: 4.0

Spawning: Apparently the spawning behavior is unknown but it is thought to spawn in backwater sloughs,

Number stocked: 26

Stocking sources: The Glades (Jersey Co.)

Stocking sites: Spunky Bottoms.

Assessment: The species has not been detected at Spunky Bottoms.

Spunky Bottoms

This species was not stocked until 2009. At total of 26 large adults were stocked and are expected to become established. The small number stocked and high water likely prevented any being detected this year. Future monitoring should detect a growing population.

Pumpkinseed- *Lepomis gibbosus*

Diet: This species is a very opportunistic feeder, and will feed on insects, crustaceans, plankton, fish eggs, other fishes, and snails. In some populations, pharyngeal jaw muscles are specially adapted for crushing snail shells.

Habitat: This species occurs in clear, well-vegetated lakes and ponds, as well as quiet pools of streams and small rivers.

Trophic Level and Community Role: 3.3

Spawning: This species spawning behavior is similar to that of other *Lepomis* species. Pumpkinseeds will construct colonial nests in shallow water in late spring to early summer. Parental care of the eggs is common.

Number stocked: 1691

Stocking sources: Mt. Olive City Reservoir (Macoupin Co.), Banner Marsh Pond (Fulton – Peoria Cos.), Mickelsons Landing Mississippi River, (Carroll Co.)

Stocking sites: Emiquon, Spunky Bottoms

Assessment: The species is established in Thompson Lake and possibly in Spunky Bottoms.

Emiquon

A total of 300 Pumpkinseeds was stocked into Thompson Lake. In 2008 and 2009 visual search with dipnet, trap nets, and shockboat surveys all found significant numbers of both young of the year and larger Pumpkinseeds all throughout the lake. This species is one of the most common fishes at Emiquon. The strong macrophyte population provides refuge from the predatory fishes, and the significant number of snails and other invertebrates offer an excellent forage base for this species.

Spunky Bottoms

A total of 27 adult Pumpkinseeds was stocked along telephone line road at Spunky Bottoms in 2007. No other adults or young were recovered in assessments in 2007 and 2008. In early June 2009, an additional 1364 young and adults were stocked at the overlook. Using boat electroshocking, six individuals were found primarily in the east side of the lake in September 2009. This area had more of a sand and gravel substrate that may be more attractive to this species than the soft mud substrate in other areas of the lake. Likely, 27 adults were not have been enough to establish a population especially in the wide fluctuations in habitat conditions. The second stocking may have been enough if conditions are suitable for their establishment. The wide dispersal of individuals does indicate that they will scatter widely in a fairly short time. It is still too early to say that the species has been firmly established in the lake. The species should be further monitored. Note that the lake was independently sampled by the INHS Havana laboratory in fall of 2009. They found no Pumpinkseed using boat electroshocking.

Comments: All methods of sampling Pumpkinseeds proved to be effective in their capture. It is very common in the vegetated shallows of Thompson and Flag lakes. Angling at Emiquon has established the State size record for the species.

Warmouth- *Lepomis gulosus*

Diet: The diet consists of crayfish, aquatic insects, and other fish. It can be considered more piscivorous than other *Lepomis* species, but not so much as the Crappies.

Habitat: This species prefers clear, well-vegetated water with a soft bottom. It is found in lakes, ponds, swamps, and streams. Often associated with sunken woody habitat.

Trophic Level and Community Role: 3.4

Spawning: This species will construct and guard nests similar to other sunfishes. It prefers to build nests near cover over silty debris, rather than the cleaner substrate of other *Lepomis* species.

Number stocked: 80

Stocking sources: Spring Lake (Mason County), Big Lake, Fulton County Camping & Recreation Area (Fulton Co.), Mickelsons Landing Mississippi River

Stocking sites: Emiquon

Assessment: The species is established at Emiquon.

Emiquon

A total of 80 Warmouth was stocked into the main lake body and ditches at Emiquon in 2007 and 2008. Even with this relatively small number of brood stock, the species can be found throughout much of the lake.

Comments: The species can be collected through a variety of methods: electroshocking and trap nets. Minifyke nets seemed very effective in collecting the species.

Orangespotted Sunfish- *Lepomis humilis*

Diet: The diet is very similar to that of other sunfishes including a wide variety of food items, but primarily feeds on aquatic insects including chironomid larvae.

Habitat: This species is found in lakes, streams, ponds, and large and small rivers. In streams this species prefers pools with silt or mud bottoms. Is more tolerant of turbid waters than other sunfishes.

Trophic Level and Community Role: 3.6

Spawning: The spawning of the Orangespotted sunfish is very similar to that of other sunfishes. In May, eggs will be laid over excavated nests and will be guarded by the males. Fry will hatch in approximately one week.

Number stocked: 1365

Stocking sources: Vermillion River, McKee Creek (Pike Co.), Spring Lake Ditch Overflow and Fish Creek (Mason Co.), Big Lake/Rice Lake, Anderson Lake, (Fulton Co.), Kelly Creek (Ford Co.)

Stocking sites: Emiquon, Hennepin-Hopper, Spunky Bottoms

Assessment: The species has been found in Spunky Bottoms but not at Emiquon or Hennepin-Hopper.

Hennepin-Hopper

A total of 57 individuals was stocked into nursery enclosures constructed in the waters just near the boat ramp. The enclosures, constructed from PVC pipe and seines, were designed to offer some individuals refuge from predatory fishes in the lake. The design, however, proved to be ineffective and the fish escaped. No Orangespotted sunfish have been found in any surveys and the status of the population is unknown. The area of

enclosures appeared to have suitable habitat, a mix of firm and soft bottoms. The species is still a suitable candidate for stocking after the lake's rehabilitation in 2010.

Emiquon

A total of 959 Orangespotted sunfish was stocked into Emiquon in 2007 and 2008, the majority of which were stocked into the main body of the lake near pumphouse road and some of the ditches. However, juvenile Orangespotted sunfish closely resemble Bluegill and Pumpkinseeds, so fish previously identified as such may have actually been Orangespotted Sunfish. However, enough adults were stocked that they would be recognized if caught.

Although 124 individuals were stocked into ditch KK in 2008, none have been found in or near the ditch as we did for the Starhead topminnow (*Fundulus dispar*). Given the relatively large number of this species that was stocked, we expected the species to establish itself.

Spunky Bottoms

A total of 349 individuals was stocked at Spunky Bottoms. Of these stocked in 2007, 347 were placed in the end of the stocking ditch along telephone line road and in the shallow area just on the south side of the road. Interestingly, this species was never detected in this area using a variety of methods: boat electroshocking, backpack electroshocking, visual search with a dipnet, and various traps nets.

More interesting is that they then were found on the east side of the lake just north of the boat ramp. The distance (approximately 0.52 miles) seems rather large for a small sunfish to travel but it does point out the ability of the species to seek out better habitat. This dispersal ability also suggests that other sunfishes are likely to be able dispersers. It again suggests that a site selected for stocking may not be what the stocked species is looking for and that several sites might be stocked if a sufficient number are available.

Comments: Although still relatively common in Illinois, the Orangespotted Sunfish was probably more common historically. Old data from the Havana area shows that this species would have been common in these types of backwater lake environments.

Because of their small size and local availability, this species was used to dectermine if enclosures in situ could be used to raise stock for subsequent stocking into the lake. This method may be desirable for a number of reasons but particularly if the adults are to be closely monitored for reproductive activities and collection of young. The use of netted enclosures was experimented with at Thompson Lake. Eight enclosures were stocked with one male and one female each. Monitoring the enclosures found that only one juvenile in one enclosure, although with a 1/4" mesh, small individuals could have left the enclosure. However, samplings around the enclosures from that time through fall of 2009 found no Orangespotted sunfish. Based on this, enclosures should only be used if isolated ditches or ponds are unavailable for stocking. Certainly, this was an experiment and with additional trials, improved designs could be developed.

Also, this species exhibits phenotypic differences (forms) between stream and lake populations. These differences can be important if the river form is used to stock

lake environments and vice versa. Because of possible differences in swimming and eating abilities, a stream form may be less desirable for stocking than a lake form when stocking a lake. Half of the enclosures (four) had stream pairs and the other half had lake pairs. Results suggest that lake forms grew larger than the stream form and both forms had decreased body condition. Neither of these findings was statistically significant but if a lake form can be used to stock a lake, then it should be used. A full account of the enclosure experiment is available in Appendix 3. This experiment is part of the Master's thesis of Mr. Thomas Bland.

Orangespotted sunfish are typically smaller than other sunfish species, making them more susceptible to predation. There appears to be a negative survival correlation with clear water, dense aquatic vegetation and predator density. Unless a large number of individuals can be initially obtained, the use of some sort of nursery enclosure or pond/ditch area is recommended. For collecting brood stock, backpack shocking and electroshock boats were effective methods although a bag seine can be useful in the right situation.

Redspotted Sunfish- *Lepomis miniatus*

Diet: This species consumes mostly aquatic insects and zooplankton.

Habitat: This species is found in lakes and streams and almost always in association with aquatic vegetation.

Trophic Level and Community Role: 3.5

Spawning: Nests of this species are constructed over sand or gravel in shallow water, similar to other *Lepomis* species. Nests are sometimes built in colonies.

Number stocked: 4000

Stocking sources: Illinois Natural History Survey experimental pond (Champaign Co.)

Stocking sites: Emiquon

Assessment: This species is established and reproducing in the rare fish refuge at Emiquon.

Emiquon

Approximately 4000 Redspotted sunfishes were stocked into the rare fish refuge west of the highway in 2008 (Fig. 5). The preserve area has clear water with lots of vegetation and contains no predators. The population is well established within the lake.

Comments: We assisted Trent Thomas and Rob Hilsabeck (IDNR) and T. Hobson (TNC) with establishing this species at the rare fish refuge at Emiquon. The Redspotted sunfish is currently listed as endangered by the Illinois Department of Natural Resources.

The species was once more common than is currently, and the decline is likely to due to lower water quality and less suitable habitat. In early 2008, 24 adults captured from Fish Creek were stocked into brood ponds operated by the Illinois Natural History Survey. Over 4000 individuals were removed from the ponds only a few months later, and most were stocked at the rare fish refuge. Those individuals probably represent a significant portion of the state's population of Redspotted sunfish.

As evidenced by the use of brood ponds, this species is very fecund. The species could be moved from the preserve to Thompson/Flag lakes in the future. At Emiquon there exists a unique opportunity to bring this species back from decline, hopefully to the point where it can someday be de-listed.

Golden Shiner- *Notemigonus crysoleucas*

Diet: The species is primarily a surface feeder, its diet includes zooplankton, algae, and terrestrial and aquatic insects.

Habitat: The species is found in lakes, streams, rivers, and swamps. It is considered relatively tolerant of low water quality.

Trophic Level and Community Role: 2.6

Spawning: The species spawns from late April to early June. Eggs are usually broadcast over vegetation, but spawning has been observed over nests of other species.

Number stocked: 45

Stocking sources: Hennepin Canal State Park (Bureau Co.), Beaver Creek (Clinton Co.), Missouri Creek (Schuyler County)

Stocking sites: Emiquon, Spunky Bottoms

Assessment: This species has been detected at Emiquon and is probably reproducing in the lake. This species has not been detected as Spunky Bottoms.

Emiquon

A total of 110 individuals was stocked into Emiquon in 2007 and 2008. Of these 65 Golden shiners were stocked into ditch U in 2007 (Fig. 5). Another 45 Golden shiners were stocked into the main lake body near the boat ramp in May of 2008. Considering the size of the lake, heavy predation, and fairly limited number of individuals stocked, we were pleased that two individuals were captured at the north end of the lake in 2009. The small size of the individuals caught suggests that the species spawned in 2007. This species is the only native cyprinid to be established in the lake.

Spunky Bottoms

Only 12 individuals was stocked in 2009. Even if the species begins to be established, it may be a few years before it can be detected. Conditions for the species at the lake appear good and additional individuals should be stocked in the future.

Comments: The Golden shiner was commonly found in Thompson and surrounding lakes, and remains a common fish in Illinois. The species is tolerant of a wide variety of habitat types and qualities although Emiquon provides prime habitat for the species. This species is also a nest associate with the Largemouth bass (*Micropterus salmoides*). Golden shiners spawn over the nests of the bass. The eggs and larvae of the shiners then receive parental care from the bass parents.

This species should also be considered for Hennepin-Hopper after the rehabilitation in 2010. Additional numbers should be put into Spunky Bottoms as well. Very high numbers of Gizzard shad (*Dorosoma cepedianum*) are present in Spunky Bottoms and may be having negative effects on the system. The Golden shiner could be an effective competitor to this species. It is also the most suitable native cyprinid species for Spunky Bottoms.

This species can be captured at many sites across the state. Electroshocking methods work well as methods of capture while seining in heavy vegetation is difficult to do effectively.

Emerald Shiner- *Notropis atherinoides*

Diet: The species feeds mostly on zooplankton, algae, and aquatic and terrestrial insects.

Habitat: This species prefers rivers and lakes, but is sometimes found in smaller streams. It prefers sand or gravel substrate and can be tolerant of turbid water.

Trophic Level and Community Role: 2.8

Spawning: The reproductive behavior of this species is not well known but probably occurs in late spring to early summer. Eggs are probably broadcast over the substrate.

Number stocked to date: 150

Stocking sources: Illinois River, river mile 135.

Stocking sites: Emiquon

Assessment: The species has not been detected at Emiquon.

Emiquon

Approximately 150 Emerald Shiners were stocked into the main lake body near the boat ramp in May of 2008. No survey has yet recovered any but this is not surprising given the large area of the lake and high numbers of predators.

Comments: Currently, the species is generally thought of as a large river species and not a common occupant of backwater lakes. However, historical records show that the Emerald shiner was present at Thompson Lake and some nearby lakes. At that time the lakes had a direct physical connection to the Illinois River, whereas our sites currently do not. So it will be interesting if this species can establish a sustaining population in the lake.

Tadpole Madtom- *Noturus gyrinus*

Diet: The diet at all ages consists of zooplankton and insect larvae. Chironomids are the most common type of larvae consumed, but this species will also eat ephemeropterans, trichopterans, and amphipods.

Habitat: This species is found in lakes and slow moving creeks and rivers. Typically it is associated with mud or organic substrates.

Trophic Level and Community Role: 3.3

Spawning: Little is known about spawning behavior in this species except that it occurs from May to early June. Nests are found under rocks or in cavities.

Number stocked: 164

Stocking sources: Red Oak Ditch (Mason Co), Silver Creek (Bond Co.), Beaver Creek (Clinton Co.), Central Ditch, Fish Creek, Kelly Creek (Livingston Co.), Mud Creek (Livingston Co.), McKee Creek (Iroquois Co.), McKee Creek (Brown Co.)

Stocking sites: Emiquon, Spunky Bottoms

Assessment: The species has not been detected at Emiquon or Spunky Bottoms.

Emiquon

A total of 43 Tadpole madtoms was stocked into Emiquon over the three years. Most were placed in quarry and ditches in 2007. In 2008, another 18 were placed along pumphouse road in 2008. None have yet been found in any survey of the lake or ditch. The species is benthic and highly inconspicuous. Likely additional stocking will be required before the species can be detected (see comments).

Spunky Bottoms

A total of 121 individuals was stocked into Spunky Bottoms. Of these 103 individuals were stocked into the ditch along telephone line road at Spunky Bottoms in early 2008. The balance was stocked in the same area in 2009. None have yet been recovered, and again we can only speculate as to the status of the population. Intensive search of this area by various methods has not detected the species (see comments). Larger common

bullhead species (*Ameiurus* spp) were caught in fairly numbers at this site and their presence may have negatively impacted the madtom.

Comments: Electroshocking methods are preferable to seining for this species as it sometimes can bury itself in the substrate, avoiding the seine. Small streams and swamps produced the most specimens for stocking. Assessing the stockings in the lake can be difficult and may explain why none have been found especially in Spunky Bottoms. Higher water levels will dilute the population and their habit of living in benthic vegetation and other structure will make them difficult to find. Baited traps may work but these carry the risk of attracting turtles, river otters, etc. Late in 2009, we tried baited minnow traps in shallow areas of Emiquon without success. Likely this failed because the attempt was late in the season. It would be worth trying again using a large number of traps in a small area. Note that unbaited traps often caught large numbers of Black and Yellow bullheads (*Ameiurus melas* and *A. natalis* respectively) at Spunky Bottoms.

Another possible sampling method is to use empty cans or pieces of PVC pipe. Madtoms utilize small cavities and are found in discarded cans and bottles. This method could be useful for monitoring spawning activities as these structures are used for spawning.

Logperch- *Percina caprodes*

Diet: The young feed on mostly cladocerans, copepods, and other zooplankton. Adults consume benthic insects including midge, mayfly, and caddisfly larvae.

Habitat: This species is common in streams and medium sized rivers with sand or rocky bottoms. Also it is found in well-vegetated backwater and oxbow lakes with mud, sand, or rock bottoms.

Trophic level and community role: 3.4

Spawning: This species spawns from late spring to early summer. The eggs are buried in the substrate, and are left unguarded.

Number stocked: 142

Stocking sources: Senachwine Creek (Peoria Co.), McKee Creek (Brown Co.), Big Lake (Fulton Co.)

Stocking sites: Emiquon, Hennepin-Hopper, Spunky Bottoms

Assessment: This species has not been detected at any of the stocking sites.

Emiquon

A total of 85 Logperch was stocked into the area near pumphouse road and the quarry in 2007 and 2008 (Fig 5). Both areas have gravel and sand substrate. No survey has yet

found any logperch, but it is likely to be in the stocked areas as it will prefer the gravel habitat.

Hennepin-Hopper

A total of 56 Logperch was stocked in the ditch west of brood ditch in 2007 (Fig. 6). The ditch was sampled by boat electroshocking in October 2008 and no logperch were found. A number of predatory species, including very large Black Crappie (*Pomoxis nigromaculatus*) and Largemouth bass (*Micropterus salmoides*) were found in the ditch, making it unlikely that any Logperch remain. Surveys in the main lake body have also yielded no Logperch.

Spunky Bottoms

Only 1 Logperch was stocked into the lake in 2007 and that individual has not been recaptured. More stocking effort will be required to establish this species.

Comments: Logperch from the creeks were collected by use of minnow seine, and those from Big Lake were collected by electro-shock boat. Both methods were fairly effective. Senachwine Creek was particularly productive, providing us with a high number of individuals with little seining effort. Although Logperch seem to be able to survive in waters with a mud/silt bottom, it prefers sandy/rocky bottoms. All three restoration sites are primarily mud-bottomed, and most of the sand or rock habitat is from the old gravel roads that were present. Stocking and assessment efforts should focus on these areas. Any sand or rock habitat that manifests itself in the future, should be included in consideration for potential Logperch stocking sites. Logperch seem to be very hardy fish, as there was less mortality during transport than other species of the same size. Monitoring should focus on these sandy/rocky areas, and can be done effectively with seine, minnow trap, backpack shocker, and boat electro-shocker.

White Crappie- *Pomoxis annularis*

Diet: The young will feed on small crustaceans and insect larvae. Adults will feed more on fishes, and are generally considered to be more piscivorous than other sunfishes.

Habitat: This species occurs in well-vegetated lakes and rivers, but also is found in ponds and slow-moving streams. It occurs over a variety of substrates.

Trophic Level and Community Role: 3.8

Spawning: This species spawns from April through June and activities are similar to that of Largemouth bass. Nests are cleared and the males will guard and fan the eggs.

Number stocked: 152

Stocking sources: Rice/Big Lake (Fulton Co.), Banner Marsh (Fulton-Peoria Cos.)

Stocking sites: Emiquon

Assessment: The species has not been detected at Emiquon.

Emiquon

A total of 152 White crappie was stocked in 2007 into the ditches. However, a small number of individuals was stocked relative to the Black Crappie (*Pomoxis nigromaculatus*) and not detecting them in a large lake might be expected. As the species is very fecund, individuals should begin to appear in samples in the next few years if it remains in the lake.

Comments: Both Black and White Crappies are desired game species, and strong populations could do much to help public opinion of the restorations. Many crappie were collected by a variety of sampling methods.

Black Crappie- *Pomoxis nigromaculatus*

Diet: Very similar to that of the White crappie, the diet is mostly piscivorous but it will also consume aquatic insects.

Habitat: Habitat preferences are nearly identical to that of the White crappie, with the exception that it may be less tolerant of turbidity than the White crappie.

Trophic Level and Community Role: 3.8

Spawning: Spawning activities are also the same as in White crappie.

Number stocked: 4330

Stocking sources: Rice/Big lakes (Fulton Co.), Hennepin-Hopper (Putman Co.), Lake Storey (Co.), Banner March (Fulton-Peoria Co.)

Stocking sites: Emiquon

Assessment: This species is established at Emiquon.

Emiquon

A total of 4330 Black crappie was stocked into Thompson Lake. Most of these were stocked into the various ditches in 2007. The sport fish assessment of the lake in 2008 by R. Hilsbeck (IDNR) indicated a large 2007-year class. It was found at a number of sites around the lake in 2009. It is readily caught using boat electroshocking and minifyke nets.

Comments: Emiquon is a very suitable lake for this species since it prefers lakes with clear water and vegetation. The suitability is also evident by the quick colonization of the lake. This population could be used to restock Hennepin-Hopper after rehabilitation in 2010.

Sauger- *Sander canadensis*

Diet: Juveniles will feed on insect larvae including chironomids, and zooplankton. The diet will shift to fishes as adults.

Habitat: This species is most commonly found in medium to large rivers over sand and gravel, as well as in backwater pools. This species is much less common in lakes and reservoirs.

Trophic Level and Community Role: 4.1

Spawning: Around April, the Sauger will congregate in shoals and broadcast spawn. Eggs will stick to rocks and hatching can take as long as three weeks.

Number stocked: 20

Stocking sources: Illinois River, Big Lake (Fulton Co.)

Stocking sites: Emiquon

Assessment: The species has not been detected at Emiquon.

Emiquon

A total of 20 individuals was stocked at Emiquon. Of these 17 Sauger were stocked into ditch KK, and three were put into the main lake at Emiquon in 2008. None have yet been recovered in any surveys of the lake or ditch.

Comments: Certainly prey is widely available and habitat appears suitable at Emiquon. From the small number stocked, the species may not become established and it may take some time before the population becomes detectable. Additional stocking is recommended. Nearby Big Lake is one possible source of this species.

Walleye- *Sander vitreus*

Diet: The young will consume zooplankton and fish fry and adults are piscivores.

Habitat: The species occupies lakes and rivers. It occurs over a variety of substrates.

Trophic Level and Community Role: 4.5

Number stocked: 410,000 fry

Stocking sources: Jake Wolf Hatchery (Mason County)

Stocking sites: Emiquon

Assessment: The species has not been detected at Emiquon.

Emiquon

A total of 410,000 fry was stocked in 2007 in the area of the boat ramp. Although a very large number of fry were stocked, the species is very vulnerable to predation. The early high numbers of large mouth bass may have eliminated it from the lake (R. Hilsabeck, IDNR, pers. comm.).

Comments: The trophic level indicates that the species feeds primarily on fishes and may be an additional means to control Common carp (*Cyprinus carpio*). Conversely, small walleye are highly preyed upon and may serve as forage for other fishes.

Central Mudminnow- *Umbra limi*

Diet: This species consumes mostly benthic invertebrates including insects, snails, and amphipods. It will also prey on aquatic beetles and some plant material.

Habitat: This species is found in streams, ponds, sloughs, and wetlands. It prefers mud bottom and dense vegetation and is tolerant of low oxygen levels, extreme water temperatures, and can be found in acidic bogs. May sometimes be the only fish species found in low quality aquatic habitat.

Trophic level and community role: 3.5

Spawning: Spawning occurs during April in Illinois. Females deposit eggs on vegetation and hatch occurs about one week later. Individuals are likely mature by the second year.

Number stocked: 250

Stocking sources: Beaver Creek (Kankakee Co.), Pond South of Henry, IL, Red Oak Ditch (Mason Co.), Crane Creek (Mason Co.), Spring Lake Ditch overflow, Central Ditch, McKee Creek (Iroquois Co.).

Stocking sites: Emiquon, Hennepin-Hopper, Spunky Bottoms

Assessment: No individuals have been found in the stocked sites.

Emiquon

In early 2007, 95 Central mudminnows were stocked into ditch KK, and only 1 was seined out when re-sampled in October of that year. In October of 2008, 40 more were stocked into ditch KK. The ditch was difficult to sample, and given that there are few predators and that it is suitable habitat for mudminnows (muddy and weedy), we believe it is likely that this species persisted in ditch KK. It may have moved into other nearby areas when the ditch was subsumed by rising lake levels in 2009 or possibly through the tile system. In 2007, 23 individuals were stocked into the main body of the lake. None have been seen since and it is unknown how well that population is doing. The lake currently has plenty of suitable habitats. The enormous size of the lake may have diluted the populations to undetectable levels.

Hennepin-Hopper

Only 3 individuals were stocked into the seep area in 2007. Visual searches with dipnets in 2008 found no mudminnows and that is not surprising given the large area to be searched. Once the Hennepin-Hopper lakes have been rehabilitated, the Central mudminnow should be re-stocked.

Spunky Bottoms

A total of 26 Central mudminnows was stocked telephone line road from 2007 to 2009, and none have been found in this area. Few individuals were stocked within a small area and a strong predator population existed, but the lake appears vegetated enough to provide suitable habitat. It does seem to prefer cooler temperatures, and if temperatures are too high, the species is unlikely to persist (Smith 1979). Before further stocking, the impact of temperate should be considered further. Otherwise, this species would be a good target for additional stocking efforts at Spunky Bottoms if the vegetation improves and water remain clear.

Comments: The restored lakes are highly vegetated and have mostly mud bottoms, which is excellent habitat for Central mudminows. Given an opportunity, populations of this species are likely to thrive in heavily vegetated areas.

Assessment efforts should focus on backpack shocking and placement of minnow traps in densely vegetated areas. Central mudminnows were collected by both minnow seine and backpack shocker. Backpack shocking is preferable as it more difficult to seine in the densely vegetated areas in which the species is found.

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APPENDIX 1a. List of species stocked and numbers stocked and assessed at Hennepin-Hopper.

Species		Hennepin-Hopper Number Stocked 2007,2008,2009	Hennepin-Hopper Number Assessed 2007,2008,2009
Ameiurus nebulosus	(Brown bullhead)	0,0,0	0,0,200
Amia calva	(Bowfin)	0,0,0	0,0,0
Aphredoderus sayanus	(Pirate perch)	25,0,0	0,0,0
Catostomus commersoni	(White sucker)	0,0,0	0,0,0
Erimyzon sucetta	(Lake chubsucker)	0,0,0	0,0,0
Esox americanus	(Grass pickerel)	11,0,0	0,0,0
Etheostoma asprigene	(Mud darter)	0,0,0	0,0,0
Etheostoma gracile	(Slough darter)	0,0,0	0,0,0
Etheostoma nigrum	(Johnny darter)	1,0,0	0,0,0
Fundulus dispar	(Starhead topminnow)	0,0,0	0,0,0
Fundulus notatus	(Blackstripe topminnow)	69,0,0	0,0,0
Ictalurus punctatus	(Channel catfish)	0,0,0	0,0,0
Labidesthes sicculus	(Brook silverside)	0,0,0	0,0,0
Lepisosteus oculatus	(Spotted gar)	0,0,0	0,0,0
Lepisosteus osseus	(Longnose gar)	0,0,0	0,0,0
Lepisosteus platostomus	(Shortnose gar)	0,0,0	0,0,0
Lepomis gibbosus	(Pumpkinseed)	0,0,0	0,0,0
Lepomis gulosus	(Warmouth)	0,0,0	0,0,0
Lepomis humilis	(Orangespotted sunfish)	27,0,0	0,0,0
Lepomis macrochirus	(Bluegill)	0,0,0	0,0,>1
Lepomis microlophus	(Redear sunfish)	0,0,0	0,0,0
Lepomis miniatus	(Redspotted sunfish)	0,0,0	0,0,0
Micropterus salmoides	(Largemouth bass)	0,0,0	0,>1,>1
Notemigonus crysoleucas	(Golden shiner)	0,0,0	0,0,0
Notropis atherinoides	(Emerald shiner)	0,0,0	0,0,0
Notropis hudsonius	(Spottail shiner)	0,0,0	0,0,0
Noturus gyrinus	(Tadpole madtom)	0,0,0	0,0,0
Percina caprodes	(Logperch)	56,0,0	0,0,0
Percina maculata	(Blackside darter)	0,0,0	0,0,0
Percina phoxocephala	(Slenderhead darter)	0,0,0	0,0,0
Pomoxis annularis	(White crappie)	0,0,0	0,>1,>1
Pomoxis nigromaculatus	(Black crappie)	0,0,0	0,0,0
Sander canadensis	(Sauger)	0,0,0	0,0,0
Sander vitreus	(Walleye)	0,0,0	0,0,0
Umbra limi	(Mudminnow)	3,0,0	0,0,0

APPENDIX 1b. List of species stocked and numbers stocked and assessed at Emiquon.

		Emiquon	
Species		Number Stocked 2007,2008,2009	Number Assessed 2007,2008,2009
Ameiurus nebulosus	(Brown bullhead)	56,23,87	0,0,14
Amia calva	(Bowfin)	42,0,0	0,>1,8
Aphredoderus sayanus	(Pirate perch)	25,0,0	0,0,0
Catostomus commersoni	(White sucker)	0,0,0	0,0,0
Erimyzon sucetta	(Lake chubsucker)	61,219,11	0,1,7
Esox americanus	(Grass pickerel)	146,0,10	0,0,0
Etheostoma asprigene	(Mud darter)	50,5,0	0,0,0
Etheostoma gracile	(Slough darter)	0,0,0	0,0,0
Etheostoma nigrum	(Johnny darter)	49,24,0	0,0,0
Fundulus dispar	(Starhead topminnow)	107,9024,170	>1,0,>180
Fundulus notatus	(Blackstripe topminnow)	236,261,1	>1,0,0
Ictalurus punctatus	(Channel catfish)	103,3,0	0,0,1
Labidesthes sicculus	(Brook silverside)	600,0,0	0,0,0
Lepisosteus oculatus	(Spotted gar)	25,31,0	0,2,4
Lepisosteus osseus	(Longnose gar)	0,14,0	0,0,0
Lepisosteus platostomus	(Shortnose gar)	0,0,0	0,0,0
Lepomis gibbosus	(Pumpkinseed)	300,0,0	>98,0,>602
Lepomis gulosus	(Warmouth)	71,9,0	0,1,>44
Lepomis humilis	(Orangespotted sunfish)	448,511,0	0,0,0
Lepomis macrochirus	(Bluegill)	1426,803,0	>1,>56,>2605
Lepomis microlophus	(Redear sunfish)	0,0,0	0,0,1
Lepomis miniatus	(Redspotted sunfish)	0, ~4000,0	0,0,>100
Micropterus salmoides	(Largemouth bass)	1274163,0,0	0,>1,>930,
Notemigonus crysoleucas	(Golden shiner)	65,45,0	0,0,2
Notropis atherinoides	(Emerald shiner)	0,150,0	0,0,0
Notropis hudsonius	(Spottail shiner)	8,0,0	0,0,0
Noturus gyrinus	(Tadpole madtom)	13,28,2	0,0,0
Percina caprodes	(Logperch)	25,60,0	0,0,0
Percina maculata	(Blackside darter)	5,0,0	0,0,0
Percina phoxocephala	(Slenderhead darter)	0,4,0	0,0,0
Pomoxis annularis	(White crappie)	151,1,0	0,0,0
Pomoxis nigromaculatus	(Black crappie)	4324,6,0	0,0,>235
Sander canadensis	(Sauger)	0,0,0	0,0,0
Sander vitreus	(Walleye)	0,20,0	0,0,0
Umbra limi	(Mudminnow)	410000,0,0	0,0,0

APPENDIX 1c. List of species stocked and numbers stocked and assessed at Spunky Bottoms.

Species		Spunky Bottoms Number Stocked 2007,2008,2009	Spunky Bottoms Number Assessed 2007,2008,2009
Ameiurus nebulosus	(Brown bullhead)	0,0,0	0,0,0
Amia calva	(Bowfin)	0,1,0	0,0,0
Aphredoderus sayanus	(Pirate perch)	29,114,71	0,0,0
Catostomus commersoni	(White sucker)	0,0,4	0,0,0
Erimyzon sucetta	(Lake chubsucker)	25,0,1	0,0,0
Esox americanus	(Grass pickerel)	7,14,29	0,1,1
Etheostoma asprigene	(Mud darter)	0,0,0	0,0,0
Etheostoma gracile	(Slough darter)	0,0,6	0,0,0
Etheostoma nigrum	(Johnny darter)	17,8,129	0,0,0
Fundulus dispar	(Starhead topminnow)	0,0,0	0,0,0
Fundulus notatus	(Blackstripe topminnow)	41,12,10	0,1,1
Ictalurus punctatus	(Channel catfish)	0,0,0	0,0,0
Labidesthes sicculus	(Brook silverside)	0,0,1	0,0,0
Lepisosteus oculatus	(Spotted gar)	0,0,1	0,0,0
Lepisosteus osseus	(Longnose gar)	0,0,0	0,0,0
Lepisosteus platostomus	(Shortnose gar)	0,0,26	0,0,0
Lepomis gibbosus	(Pumpkinseed)	27,0,1364	0,0,6
Lepomis gulosus	(Warmouth)	0,0,0	0,0,0
Lepomis humilis	(Orangespotted sunfish)	347,0,2	0,0,4
Lepomis macrochirus	(Bluegill)	0,0,26	>1,2,22
Lepomis microlophus	(Redear sunfish)	0,0,6	0,0,0
Lepomis miniatus	(Redspotted sunfish)	0,0,0	0,0,0
Micropterus salmoides	(Largemouth bass)	0,0,2	0,0,8
Notemigonus crysoleucas	(Golden shiner)	0,0,12	0,0,0
Notropis atherinoides	(Emerald shiner)	0,0,0	0,0,0
Notropis hudsonius	(Spottail shiner)	0,0,0	0,0,0
Noturus gyrinus	(Tadpole madtom)	0,103,18	0,0,0
Percina caprodes	(Logperch)	0,0,0	0,0,0
Percina maculata	(Blackside darter)	0,0,0	0,0,0
Percina phoxocephala	(Slenderhead darter)	0,0,0	0,0,0
Pomoxis annularis	(White crappie)	0,0,0	0,0,0
Pomoxis nigromaculatus	(Black crappie)	0,0,0	0,0,0
Sander canadensis	(Sauger)	0,0,0	0,0,0
Sander vitreus	(Walleye)	0,0,0	0,0,0
Umbra limi	(Mudminnow)	5,8,13	0,0,0

APPENDIX 2. List of species stocked and the size ranges of stocked individuals.

Species		Size Range (Total Length in mm)
Ameiurus nebulosus	(Brown bullhead)	173-394
Amia calva	(Bowfin)	335-666
Aphredoderus sayanus	(Pirate perch)	22-102
Catostomus commersoni	(White sucker)	---------
Erimyzon sucetta	(Lake chubsucker)	40-189
Esox americanus	(Grass pickerel)	35-260
Etheostoma asprigene	(Mud darter)	52-59
Etheostoma gracile	(Slough darter)	---------
Etheostoma nigrum	(Johnny darter)	31-63
Fundulus dispar	(Starhead topminnow)	27-73
Fundulus notatus	(Blackstripe topminnow)	20-102
Ictalurus punctatus	(Channel catfish)	305-762
Labidesthes sicculus	(Brook silverside)	76-127
Lepisosteus oculatus	(Spotted gar)	300-863
Lepisosteus osseus	(Longnose gar)	339-784
Lepisosteus platostomus	(Shortnose gar)	322-725
Lepomis gibbosus	(Pumpkinseed)	46-168
Lepomis gulosus	(Warmouth)	51-203
Lepomis humilis	(Orangespotted sunfish)	23-110
Lepomis microlophus	(Redear sunfish)	---------
Lepomis miniatus	(Redspotted sunfish)	---------
Notemigonus crysoleucas	(Golden shiner)	76-229
Notropis atherinoides	(Emerald shiner)	---------
Notropis hudsonius	(Spottail shiner)	---------
Noturus gyrinus	(Tadpole madtom)	30-95
Percina caprodes	(Logperch)	57-134
Percina maculata	(Blackside darter)	---------
Percina phoxocephala	(Slenderhead darter)	46-56
Pomoxis annularis	(White crappie)	178-381
Pomoxis nigromaculatus	(Black crappie)	152-457
Sander canadensis	(Sauger)	153-318
Sander vitreus	(Walleye)	fry
Umbra limi	(Mudminnow)	29-120

APPENDIX 3.

Phenotypic Plasticity in the Orangespotted Sunfish (*Lepomis humilis*): Implications for stocking

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Introduction

One important factor driving evolution is how well populations are able to adapt to change. These adaptations can be manifested in a number of ways such as adjustments to behavior or changes in morphology. While behavioral traits are more labile (Blomberg et al. 2003), intra-species morphological variation is still fairly common. Polymorphisms like these have been documented in amphibians, birds, and fishes (Smith and Skulason 1996).

In fishes, polymorphisms have been described in several species and in response to several different factors (summarized in Smith and Skulason 1996). Types of ecological interactions known to be associated with morphological variations are competition (Svanback et al. 2008), predation (Yonekura et al. 2007, Eklov and Svanback 2006), and cannibalism (Andersson and Persson 2005). Other factors known to be associated with polymorphisms are diet (Hegrenes 2001, Andersson 2003), resource availability (Mittelbach et al. 1992, Andersson et al. 2005, Hjelm et al. 2000), habitat (Olsson et al. 2007, Olsson and Eklov 2005, Brinsmead and Fox 2002), and water flow (Imre et al. 2002, McLaughlin and Grant 1994).

Several members of the North American sunfish genus *Lepomis* (Centrarchidae) are known to display some sort of polymorphism including bluegill, *L. macrochirus*, (Ehlinger and Wilson 1988, Chipps et al. 2004), and pumpkinseed, *L. gibbosus*, (Robinson and Wilson 1996, Mittelbach et al. 1999, Gillespie and Fox 2003, Vila-Gispert et al. 2007). These polymorphisms are typically classified into two distinct forms, littoral and pelagic (Robinson and Wilson 1994). The littoral form is deep bodied with relatively short fins and a large mouth. This body shape is best suited for a structurally complex environment where prey acquisition requires short bursts and less continuous swimming (Webb 1984). The pelagic form, conversely, is best adapted for open water foraging, typically feeding on zooplankton or phytoplankton. Body shape is more fusiform than the littoral form, and fins are longer. The mouth is also smaller and angled upward. This body form is more efficient for continuous swimming (Webb 1984), and the mouth more suited for open-water plankton foraging.

Recent work on the orangespotted sunfish, *Lepomis humilis*, has shown that this species can display polymorphisms in response to both diet (Helgrenes 2001) and habitat (Bland in prep). Lake populations of *L. humilis* in Illinois are deeper bodied, have shorter caudal peduncles, and shorter fins than stream populations. This is similar to polymorphisms seen in other studies on rock bass, *Ambloplites rupestris*, pumpkinseeds (Brinsmead and Fox 2002) and rainbow fish, *Melanotaenima sp.*, (McGuigan et al. 2003).

L. humilis is one species being stocked as part of an on-going project to restore native fish communities at three restorations along the Illinois River. Since this species is not grown at any hatchery, it can be difficult to find enough wild individuals to ensure stocking success. Therefore, we must seek to determine whether the polymorphisms between lake and stream populations can have any effect at all on stocking. The relationship between morphology and ecology is well-known, especially in sunfishes (Wainwright 1996). These morphological differences between populations could have significance with regards to performance. In fact, differences in feeding and habitat-use efficiency resulting from different morphologies have been described in several fish species including perch, *Perca fluvatilis L.*, (Svanback and Eklov 2004) arctic charr, *Salvelinus alpinus*, (Andersson 2003), threespine stickleback, *Gasterosteus aculeatus*, (Robinson 2000, Malmquist 1992, Ibrahim and Huntingford 1988, Schluter 1993), common bream, *Abramis brama*, white bream, *Blicca bjoerkna*, roach, *Rutilus rutilus*, (Nagelkerke and Sibbing 1996), yellow perch, *Perca flavescens*, (Boily and Magnan 2002), and brook trout, *Salvelinus fontinalis*, (McLauglin et al. 1994, Boily and Magnan 2002).

In the case of yellow perch it was shown that morphological characteristics, similar to those in stream populations of orangespotted sunfish, directly influenced drag and thrust while swimming, and thereby affecting swimming efficiency (Boily and Magnan 2002). These characteristics, while useful when living in a lotic habitat, are less adapted to feeding in a lentic habitat where foraging requires short, un-sustained bursts.

The implications for stocking is that to maximize stocking success, we must determine whether or not lake individuals will survive better in a lake environment than stream individuals, therefore influencing our choice of source populations. I predict that fish from lake populations will forage more efficiently in a lake environment than fish from stream populations, and will therefore have faster growth rates and survive and reproduce better.

Methods

To test this, I constructed a series of eight fish enclosures at the Nature Conservancy's Emiquon Preserve located near Havana, IL along the Illinois River. Four enclosures were stocked with orangespotted sunfish collected from lakes, and four stocked with fish from streams. The enclosures were originally conceived from a similar design made by Wayne Herndon of the Illinois Department of Natural Resources. The tops and bottoms of the enclosures were constructed of a 6ftX6ft square PVC pipe frame connected by 1/4in mesh seine. The bottom frame was covered by a larger mesh alewife netting, and the tops covered by bird netting. A fence post was placed in each corner and the bottom frame was held down by cement blocks. The top frame was tied to the fence post and sat 2-3ft above the surface of the water. Two rows of enclosures were placed in an area of the lake with a relatively flat bottom and 2-3ft of water at the time. See Figure 1 for experimental design. The enclosures were allowed to sit in the water at least one week before fish were stocked. This allowed macroinvertebrates to colonize the insides of the enclosures and helped to ensure there was enough for the fish to forage on. Over the course of the experiment, invertebrates were common in the enclosures, particularly odonate larvae, adult spiders, and snails.

One male and one female were stocked into each enclosure to minimize the effects of competition and to eliminate any same-sex aggression (Miller 1963). The first individuals were stocked on 7-10-09, and were collected using backpack shocker from Kelly Creek, located in Ford Co. Illinois. Fish stocked on this date were not weighed and measured prior to stocking since they appeared to be stressed. Since we did not catch enough females for all stream enclosures, more fish were collected from Mud Creek located in Livingston Co. Illinois, on 7-18-09. These females were stocked into enclosures numbers 1 and 6. All lake fish were collected using electro-shock boat on 7-24-09 from Rice Lake in Fulton Co. Illinois.

Fish were removed from the enclosures with a dip net every 1-2 weeks in order to be weighed and measured. Recapture rate on any given day was on average fifty-percent. Best results were achieved when I entered the enclosures and splashed around and made every attempt to scare the fish into the other half of the enclosure. I then searched the corners and in the folds with the net. Both quick and slow movements of the net were successful. Duckweed and algae were removed from the enclosures when sampled, and would often be very thick. The experiment lasted until mid-September, 2008 when high water swamped the enclosures and many fish escaped.

Change in weight and total length was calculated based on the earliest and latest dates that data was taken for each fish. Body condition (K) was also calculated in this manner using the formula K= weight/length^3 (Helfman et al. 2007). Two individuals were removed from statistical analysis. The male in enclosure #7 was found dead on 8-8-09, and the female in enclosure #8 was never recaptured.

Results and Discussion

Table 1 shows the results of the t-tests for mean length, weight, and body condition. While there was no significant difference in weight change between lake and stream fish, there were differences in both total length and body condition. Lake fish grew 1.57 mm more in total length during the course of the experiment than stream fish. This is consistent with the prediction that lake fish would grow faster than stream fish. However, this prediction is not seen in the comparative weights and both groups lost weight, on average, over the course of the experiment. Decrease in body condition was also seen in both groups, and was significantly less in stream fish than in lake fish. This result is likely due to mixed results in length and weight data.

Sex had no effect on the length and K, but had an impact on average weight change. There was no significant difference between males and females (p=.28). Table 2 shows results of a single factor ANOVA grouped by all site-sex combinations and shows significant differences between groups, but no consistent effect from sex or site type. While mean weight change was equal for males and females from streams, there was a big difference between males and females from lakes. Lake females were the only group to gain weight at all, but lake males were the group that lost the most weight.

The experiment ended prematurely when the enclosures were flooded, and that may be one cause for the inconsistencies in the data. Also, the enclosures were not completely fish-proof. While they did an excellent job of keeping fish in (with the possible exception of the female in #8), I routinely removed other fish species from the enclosures while sampling. Some of these may have escaped through through the mesh

while small grew too large while inside to swim out. However, I don't believe that this is the case for all of the intruders as some were just too large for that to have happened. As of yet, I am completely unable to explain their presence in the enclosures. All seams were tightly sewn together and were checked whenever the enclosures were sampled. The bottoms sat solidly on the substrate and I never found any holes in the side panels. There is also some evidence that the orangespotted sunfish spawned while in the enclosures. In August, a juvenile was found in one of the enclosures. Spawning may have occurred in more than one enclosure since the mesh was large enough for the juveniles to swim through.

Although lake fish grew slightly more in length than stream fish over the course of the experiment, it would be premature to claim this as evidence that lake fish grow and forage better in a lake environment than stream fish, due to the consistencies in the other measurements. The events that probably caused the inconsistencies are unfortunate, but underscore the difficulty in doing field experiments in ecology.

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Figure 1: Experimental design of fish enclosures constructed and Emiquon

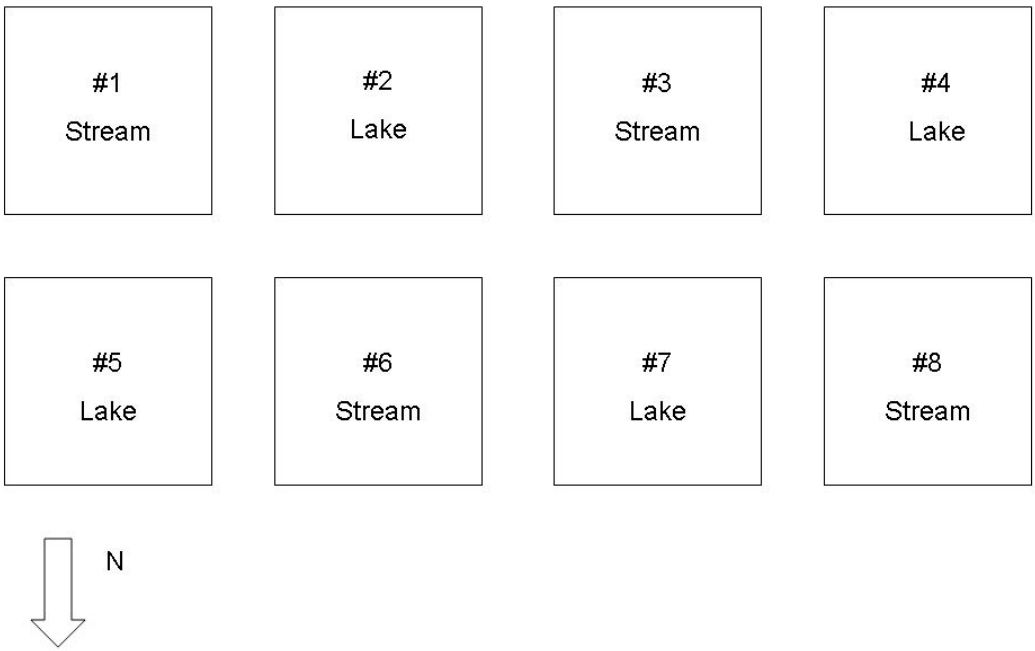

Table 1: T-test results for change in length, weight, and body condition (k) for orangespotted sunfish collected from lakes and streams.

	Lake	Stream
n	7	7
Mean Length Change (mm)	1.57	0
Standard Deviation	.95	2
p	.062	
Mean Weight Change (g)	-.61	-.76
Standard Deviation	1.23	.043
p	.78	
Mean K change	$-1.8 * 10^{-6}$	$-1.1 * 10^{-6}$
Standard Deviation	$2.54 * 10^{-12}$	$9.44 * 10^{-13}$
p	.09	

Table 2: ANOVA results for weight change in male and female orangespotted sunfish collected from both lakes and streams.

SUMMARY

Groups	*n*	*Average*	*Variance*
Lake F	4	1.75	1.583333
Lake M	3	-1.33333	2.123333
Stream F	3	-0.83333	0.643333
Stream M	4	-0.7	0.42

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	21.24881	3	7.082937	6.135954	0.012293	3.708265
Within Groups	11.54333	10	1.154333			
Total	32.79214	13				