Report for 2002ND9B: Evaluation of walleye to suppress fathead minnow populations in Type IV & V wetlands.

There are no reported publications resulting from this project.

Report Follows:

Evaluation of walleye to suppress fathead minnow populations in Type IV & V wetlands

ND WRRI Graduate Research Fellowship Project
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Abstract

Changes to the landscape of the prairie pothole region over the last hundred years, primarily due to agriculture, have caused the consolidation of temporary, seasonal, semi-permanent, and permanent wetlands, creating large Type IV and V wetlands. These larger, deeper wetlands are consistently found to be in a turbid state. The increase in the depth of many prairie wetlands due to drainage and consolidation has caused a decrease in the frequency and extent of summer and winter anoxia. Historically such harsh conditions have kept fathead minnow populations in check. Fathead minnows now persist on a more permanent basis, and population densities often become very high, with repercussions throughout the food web. The high densities of fathead minnows reduce zooplankton and macroinvertebrate diversity and abundance. Reductions in zooplankton in turn directly contribute to very high abundances of algae, which are directly associated with increases in turbidity and degraded water quality. The high turbidity causes a reduction in macrophyte diversity and abundance. The overall degradation of wetlands deters waterfowl use, as many waterfowl species are dependent upon zooplankton, macroinvertebrates, and macrophytes as major food sources. The degradation of prairie pothole wetlands as a result of fathead minnow infestations is a steadily increasing problem. Innovative, effective ways to control the distribution and abundance of fathead minnow populations in wetlands throughout the Prairie Pothole Region are needed by wetland managers. The purpose of this project is to assess one possible tool that could be used by wetland mangers to improve conditions in degraded wetlands. The project also focuses on the effectiveness of wetlands as rearing sites for walleyes for subsequent stocking in lakes. Wetlands are already used for walleye rearing, but the net effects the walleyes may have on the wetlands themselves are not clear. The expected effect of adding walleyes to type V and IV wetlands with fathead minnows is that of a "trophic cascade". The bwalleyes should decrease densities of fathead minnows. The decrease in fathead minnows should allow zooplankton and invertebrate diversity and densities to increase. The increase in zooplankton, particularly Daphnia, should cause a decrease in alga standing stock, which will increase water clarity (or decrease in turbidity). The decrease in turbidity should allow macrophytes to increase in diversity and abundance. The decrease in turbidity and increases in zooplankton and macrophytes should also increase use of the wetlands by waterfowl. The survival and growth rates of the walleyes are expected to high.

REGIONAL WATER PROBLEM

Changes to the landscape of the prairie pothole region over the last hundred years, primarily due to agriculture, have caused the consolidation of temporary, seasonal, semi-permanent, and permanent wetlands, creating large Type IV and V wetlands. These larger, deeper wetlands are consistently found to be in a turbid state. The increase in the depth of many prairie wetlands due to drainage and consolidation has caused a decrease in the frequency and extent of summer and winter anoxia. Historically such harsh conditions have kept fathead minnow populations in check. Fathead minnows now persist on a more permanent basis, and population densities often become very high, with repercussions throughout the food web. The high densities of fathead

minnows reduce zooplankton and macroinvertebrate diversity and abundance. Reductions in zooplankton in turn directly contribute to very high abundances of algae, which are directly associated with increases in turbidity and degraded water quality. The high turbidity causes a reduction in macrophyte diversity and abundance. The overall degradation of wetlands deters waterfowl use, as many waterfowl species are dependent upon zooplankton, macroinvertebrates, and macrophytes as major food sources. Innovative, effective ways to control the distribution and abundance of fathead minnow populations in wetlands throughout the Prairie Pothole Region are needed.

LITERATURE SUMMARY

The steady increase in land use for agriculture has resulted in consolidation of smaller shallower wetlands in the Prairie Pothole Region, creating large Type IV and V wetlands (Stewart and Kantrud 1971). The lower probability of these larger and deeper wetlands producing anoxic conditions has permitted for major increases in fathead minnow (*Pimephles promelas*) populations. Fathead minnows are a native species and are the most common fish in prairie wetlands (Peterka 1989) but their distribution is limited by the harsh conditions in prairie potholes, particularly anoxia. Fathead minnows have a very dynamic life history that under favorable conditions allows populations to grow exponentially into high densities (Held and Peterka 1974; Payer and Scalet 1978; Carlson and Berry 1990; and Duffy 1998). Due to this high reproductive potential, fathead minnows in wetlands without periodic anoxia can reach very high densities very quickly. The rapid growth and high food consumption of fathead minnows cause them to have critical influences on energy flow in wetlands. Fathead minnow diets consist predominantly of crustaceans and aquatic insects (Held and Peterka 1974). Fatheads' ability to grow so quickly and to have such a profound influence on a wetland's fauna stems from their ability to consume prey with both filter-feeding and particulate feeding methods (Hambright and Hall 1992).

The extremely high densities of fathead minnows found in the larger Type IV and V wetlands results in some negative effects on those waterbodies. Reduced abundances, biomass, and species richness in common orders of invertebrates were reported by Hanson and Riggs (1995), and Zimmer et al. (2000) documented dramatic shifts in invertebrate community composition when minnows were present. Increases in nutrient levels, phytoplankton biomass, and turbidity were seen in experimental wetlands stocked with fathead minnows (Hanson et al. 1995). Zimmer et al. (2001) found that fathead minnows directly and indirectly affect the nutrient partitioning within a wetland, with wetlands that have low macrophyte abundance and high fathead minnow densities being in a turbid state. The increase in nutrient recycling provides more nutrients available to phytoplankton, allowing them to grow and increase in density. One might expect, in response to the increase in phytoplankton, an increase in zooplankton densities, but the high feeding efficiency of fathead minnows does prohibit the increase in zooplankton, resulting in an overall increase in turbidity. Also, macrophyte communities deteriorate under the highly turbid conditions. Plant abundance and species composition decrease due to increased light attenuation (Hansel-Welch et al. in press). Nutrient recycling rates are increased in part due to the increased density and the feeding efficiency of fathead minnows and the absence of macrophytes, both of which contribute to greater turbidity (Scheffer et.al. 1993; Hanson and Butler 1994).

Previous studies evaluated ways of controlling fathead minnows but no methods have had a high success rate. In one study conducted by Zimmer (2001), rotenone was applied to ten Minnesota wetlands containing fathead minnows. Only one treatment out of the ten was successful in eradicating the fathead minnow population. In another study, commercial harvesting of fatheads

was applied to two South Dakota wetlands, but had little influence on the fathead minnow populations (Duffy 1998).

The application of "biomanipulation" to control fathead minnow populations is based on the concept of a top-down effect of predation causing a "trophic cascade" (Carpenter et. al. 1985; Carpenter and Kitchell 1988). The idea is that the introduction of a top predator can alter the entire trophic structure of a system. In the case of wetlands, the top predator is a piscivore (walleye), intentionally stocked to decrease and regulate the planktivores (fathead minnows), allowing the herbivores (zooplankton) to increase and flourish. The flourishing zooplankton in turn regulate the phytoplankton by grazing. This reduction of algae also slows down nutrient recycling because nutrients are retained by the zooplankton and piscivores. The net result hoped for is a shift of the system from a turbid water state to a clear water state. The clear water state will allow the resurgence of macrophytes, which in turn contribute to suppression of algae via several mechanisms (Scheffer 1998; Moss et al. 1996). The macrophytes will also decrease turbidity by not allowing the sediment to be stirred up of the bottom by wave action created by the wind.

The use of piscivorous fish to limit fathead minnow densities and improve water quality has shown some success in previous studies. A study in a South Dakota pond showed a significant decrease in fathead minnow densities during the summer growing season due to walleye (*Stizostedion vitreum*) predation (Walker and Applegate 1976). Northern pike (*Esox lucius*) and largemouth bass (*Micropterus salmoides*) have also shown promise for suppressing fathead minnow populations (Elser et. al. 2000; Spencer and King 1984). Stocking piscivorous fish in wetlands that are already fishless can have negative effects on the wetland. Reed and Parsons (1999) reported that walleye rearing in a fishless wetland did appear to reduce densities of some invertebrate orders, and recommended that walleye rearing cease in fishless ponds.

The uncertainty surrounding the effects that stocked piscivorous fish may have on a wetland ecosystem has prevented managers from using this method to control fathead minnow populations. The rising problem of deteriorating wetlands has pushed this issue to the forefront. There is as of yet no information indicating negative effects from walleye rearing in wetland ponds already containing fathead minnows. If the current evaluation of walleye stocking proves to result in improvements in wetland water quality and other ecosystem characteristics, this technique may hold benefits for the management of both wetlands and fisheries.

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OBJECTIVES OF THE PROPOSED RESEARCH.

The degradation of prairie pothole wetlands as a result of fathead minnow infestations is a steadily increasing problem. Wetland managers need effective tools to deal with this problem. The purpose of this project is look at one possible tool that could be used by wetland mangers to improve conditions in degraded wetlands. The project also focuses on the effectiveness of wetlands as rearing sites for walleyes for subsequent stocking in lakes. Wetlands are already used for walleye rearing, but the net effects the walleyes may have on the wetlands themselves are not clear. With these two overall objectives in mind, the intent of the project is to test the following hypothesis:

- H_1: The biomass of fathead minnow populations will decrease following the introduction of walleye.
- H_2: The densities of cladocerans, amphipods, dipterans, and corixids will increase following the introduction of walleye.
- H_3: Water clarity will increase in the ponds following the introduction of the walleyes.
- H_4: The density of submerged aquatic plants will increase following the introduction of walleye.

METHODS, PROCEDURES, AND FACILITIES.

This research is part of a collaborative effort between the Minnesota Department of Natural Resources, NDSU, and SDSU. Other participants are focusing on the fisheries aspects of the study, while I am responsible for investigating responses of water quality, invertebrate communities, and plants.

Study sites and design

Eighteen semi-permanent type IV and V wetlands with established fathead minnow populations were randomly chosen for this two-year study from forty possible wetlands in the Minnesota Prairie Pothole Region. The selected ponds are distributed from the middle of Clay County south to the southern end of Big Stone County and east to Douglas and Pope Counties. The

eighteen chosen wetlands were then randomly assigned to one of three treatments, with six sites in each treatment. The three treatments are: 1) walleye fry, 2) advanced-stage walleye, and 3) control (containing only fathead minnows). In the six walleye fry stocking treatments the fry were stocked in late spring and removed in the fall of 2001, this stocking and removal will be repeated for the second season of 2002. The six advanced-stage walleye treatments were stocked in the spring of 2001. Population estimates were taken this last fall (2001) and the walleyes were left in the wetlands to be carried over for the next year (2002). The treatments in the second year will be applied to the same wetlands as in the first year.

Sampling Methods

Fish communities:
Brian Herwig, a fisheries biologist from the Minnesota DNR office in Glenwood is working on biomass and relative abundance of fathead minnows. Matt Ward, a graduate student at South Dakota State University, is working on walleye diet, growth, and survival.

Aquatic Invertebrates:
Activity traps, a vertical column sampler, and an Ekman grab are being used to sample aquatic invertebrates. The sampling season begins in May and ends in September. Two sampling crews do the sampling, one crew samples the nine northern most ponds and the second crew samples the nine southern most ponds. Ten sampling sites are used per wetland; these sites were used for the entire sampling season. There are five sampling sites in the littoral zone around the wetland, and five in the open water zone.

Selection of sampling sites involves:
1. The approximate center of wetland is located.
2. Five transects at random compass bearings are selected.
    - Transects cannot be within 20^0 of each other.
    - All transects can not be within 180^0.
3. Two sample sites are located along each transect, one at the interface of the open water, and emergent vegetation and the second half way between shore and the center of the wetland.
4. Sites are marked with buoys and used for the entire sampling season.

Ten activity traps are deployed in each wetland monthly, hung from the site buoys for 24-hour periods. From the activity trap catches taxon richness and relative abundance of invertebrates are being analyzed. The analysis of invertebrate and zooplankton is being done at NDSU.

A vertical column sampler is used monthly at the five open water sites in each wetland. At each site two samples are taken. Taxon richness, relative abundance, and biomass (estimated from length-weight regressions) of zooplankton are being analyzed.

Twelve Ekman grab samples are collected once at the beginning of August in each wetland. Ten of these samples are taken at the 10 previously marked sample sites, and two samples are taken directly in the center of the wetland. Taxon richness, relative abundance, and biomass of invertebrates (from length-weight regressions) are being analyzed from the samples.

Macrophytes
Aquatic plants are sampled in late July using a plant rake. Ten sample sites are used, and at each site four samples (or rake throws) are taken. The ten sample sites are along transects one, three and five. The open and emergent sites on these transects are used, plus one in between the two

sites on those transects. One sample site is in the center of the wetland. Taxon richness and frequency of plant occurrence are being analyzed.

Water Quality Parameters:
Turbidity measurements are taken from the center of each wetland each month with a nephelometer. Water samples are also taken from the center of the wetland each month simultaneous with the other monthly sampling. These water samples are shipped to the Minnesota Department of Agriculture chemistry lab in St. Paul for analysis for total phosphorous, total nitrogen, Kjeldahl nitrogen, and chlorophyll *a*.

Facilities Used:
The Department of Biological Sciences at NDSU provides office and laboratory space, along with secretarial and clerical support. The laboratory provides microscopes, image analysis equipment, and computers. Chemicals (ethanol) are bought from the NDSU Chemistry Department. The majority of field equipment being used is from North Dakota State University, though the Minnesota DNR does provide some field equipment, for example a boat.

ANTICIPATED RESULTS AND BENEFITS FROM THE PROPOSED STUDY.
The expected effect of adding walleyes to type V and IV wetlands with fathead minnows is that of a "trophic cascade". The walleyes should decrease densities of fathead minnows. The decrease in fathead minnows should allow zooplankton and invertebrate diversity and densities to increase. The increase in zooplankton, particularly *Daphnia*, should cause a decrease in alga standing stock, which will increase water clarity (or decrease in turbidity). The decrease in turbidity should allow macrophytes to increase in diversity and abundance. The decrease in turbidity and increases in zooplankton and macrophytes should also increase use of the wetlands by waterfowl. The survival and growth rates of the walleyes are expected to high.

The information gained by this study will be used by state and federal wetland managers in their management decisions. The information will also be used by area fisheries managers who must decide whether using wetlands as rearing ponds is an effective way of rearing walleyes for stocking, and what the environmental consequences of this practice may be.

PRIOR WORK
The first field season ended this September. Overall the work went well, with only major problem being accuracy of the nephlometers that were used. The two nephelometers will be fixed before next season plus we also add the use of a Secchi dish. We are still processing samples taken from this summer, and have just begun the September samples. Some preliminary data from May to August are presented in Figure 1. These data are preliminary and have not been thoroughly analyzed or tested for significance, yet they are encouraging.

Figure 1. Mean Catch Per Unit Effort (24hr set) of Cladocerans in All Three Treatments

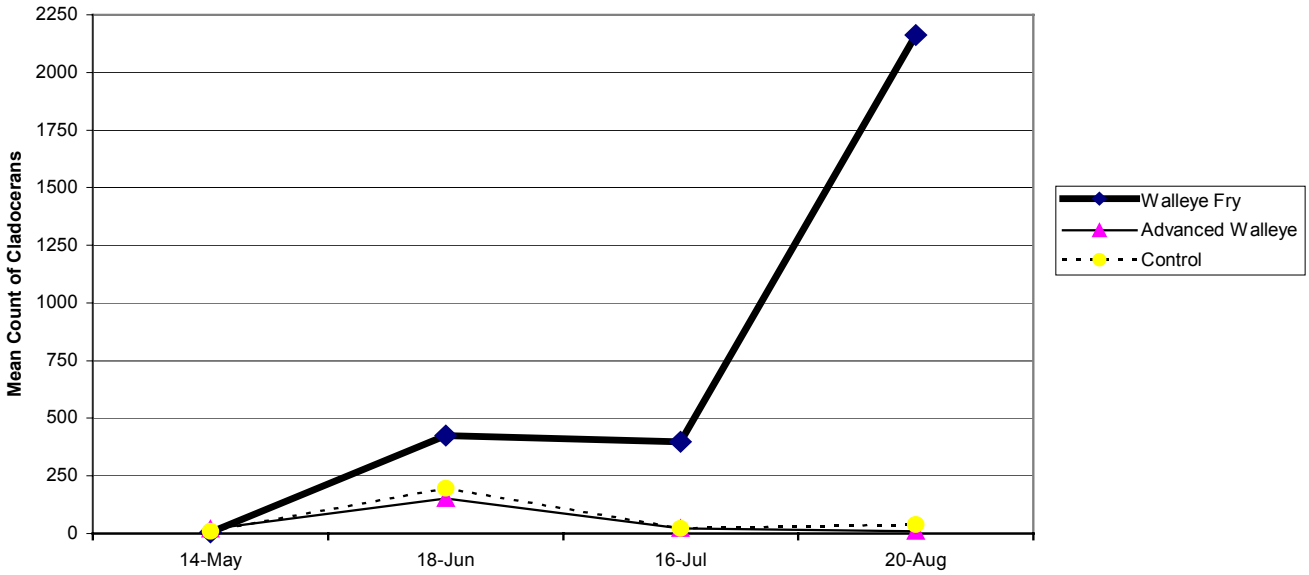


Figure 1 shows a higher densities of cladocerans in the walleye fry treatment, with an initial increase, maintainence of that increase through July, followed by a increase in August. The other treatments had a small peak in June followed by low numbers for the rest of the summer. Cladocerans are a key species in controlling alga abundances and, cladocerans are also a favorite food of fathead minnows. The trend in the fry treatments of increased cladocerans may be an indictor that the trophic cascade has occurred as hypothesized.

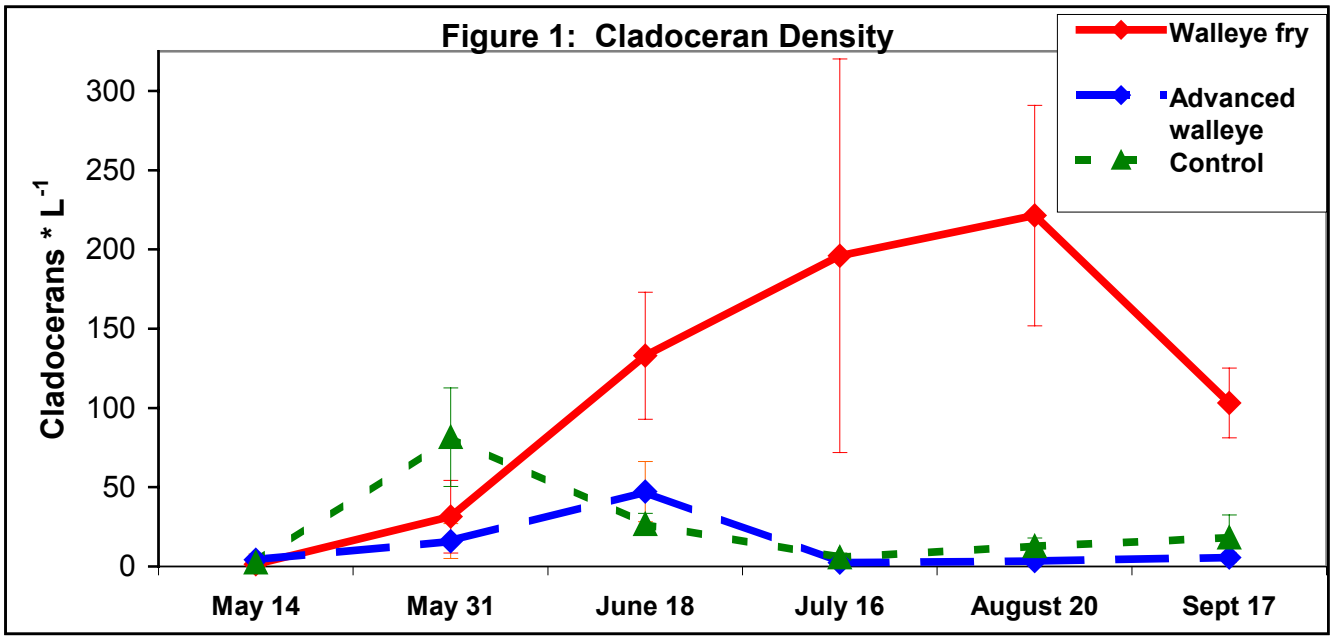
This upcoming winter the Ekman samples will be processed, biomass estimates will calculated using image-analysis and length–weight regressions, and the accumulated data from all the different parameters will be analyzed using SAS.

RESULTS

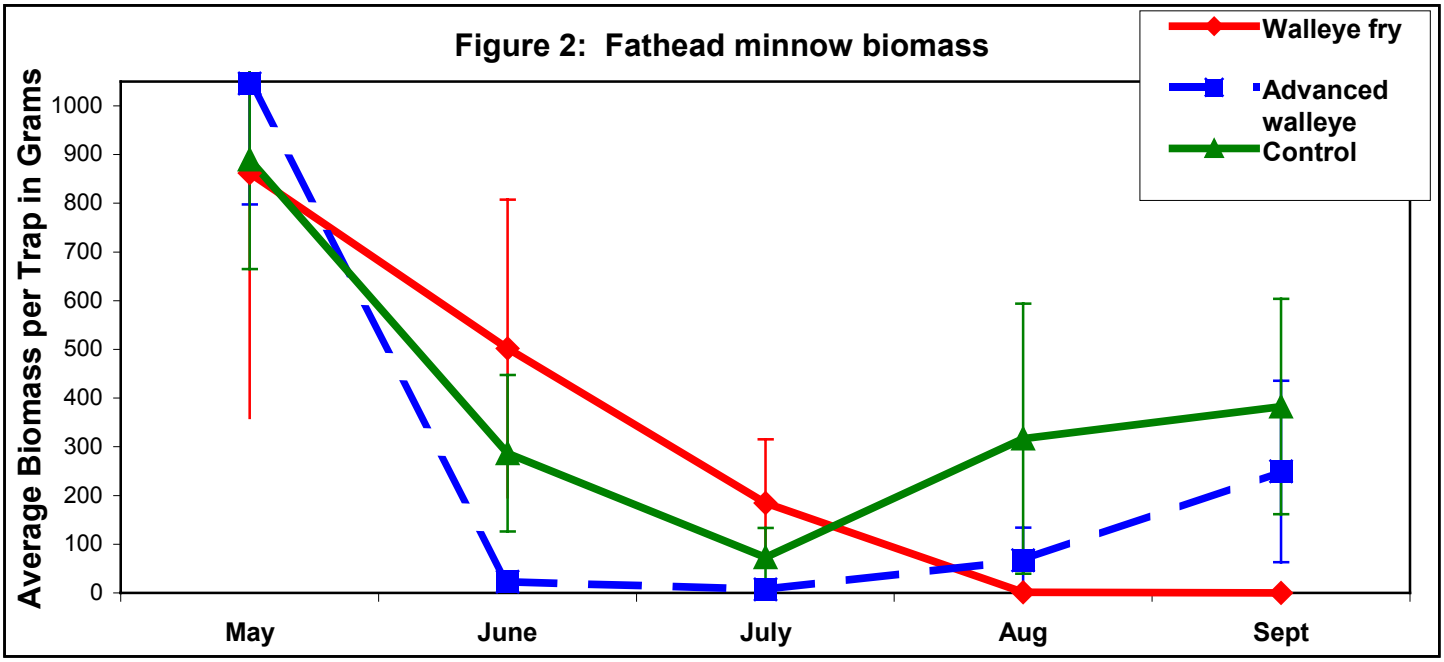
The greater depth of many prairie wetlands resulting from consolidation of smaller, more ephemeral wetlands has caused a decrease in the frequency and extent of summer and winter anoxia. As a result, fathead minnows now persist on a more permanent basis, often reaching high population densities**,** and have been found to reduce zooplankton and macroinvertebrate diversity and abundance. Reductions in zooplankton can in turn lead to increased phytoplankton**,** decreased water clarity**,** and reduced macrophyte abundance. Ultimately, these combined changes result in decreased waterfowl use. Innovative, effective ways to control the distribution and abundance of fathead minnow populations in wetlands throughout the Prairie Pothole Region are needed by wetland managers. We designed a two-year study to assess stocking of walleye fry or advanced life-stage walleye as a tool to suppress fathead minnow populations and improve water quality. All wetlands used in the study contained fathead minnow populations. Treatments consisted of 6 wetlands stocked with walleye fry, 6 wetlands stocked with adult walleyes, and 6 wetlands that were left unmanipulated (contained only fathead minnows). Response variables included measurements of the macroinvertebrate and zooplankton communities, turbidity, and multiple water quality parameters. Explanatory variables included fathead minnow biomass, macrophyte abundance, and treatments. The data analysis of the first year of data is complete. To date the majority of analyzes has followed a multivariate approach,

specifically ordinations. In addition to using ordinations to analyze the data I will also be using a mixed model ANOVA in SAS to test specific hypotheses in my continuation of this study.

In the first year of the study we observed a higher density of cladocerans in the walleye fry treatment by mid June, with a 17.5-fold increase over reference wetlands by mid August (Fig. 1). Walleye fry stocking appeared to have little effect on most macroinvertebrate populations. The trend of increased zooplankton in the fry treatment, particularly the cladocerans, corroborates our observations that walleye fry were successful in suppressing fathead minnows (Fig. 2). This



released zooplankton from predation, which led to water clarity improvements in some walleye



fry treatment ponds.

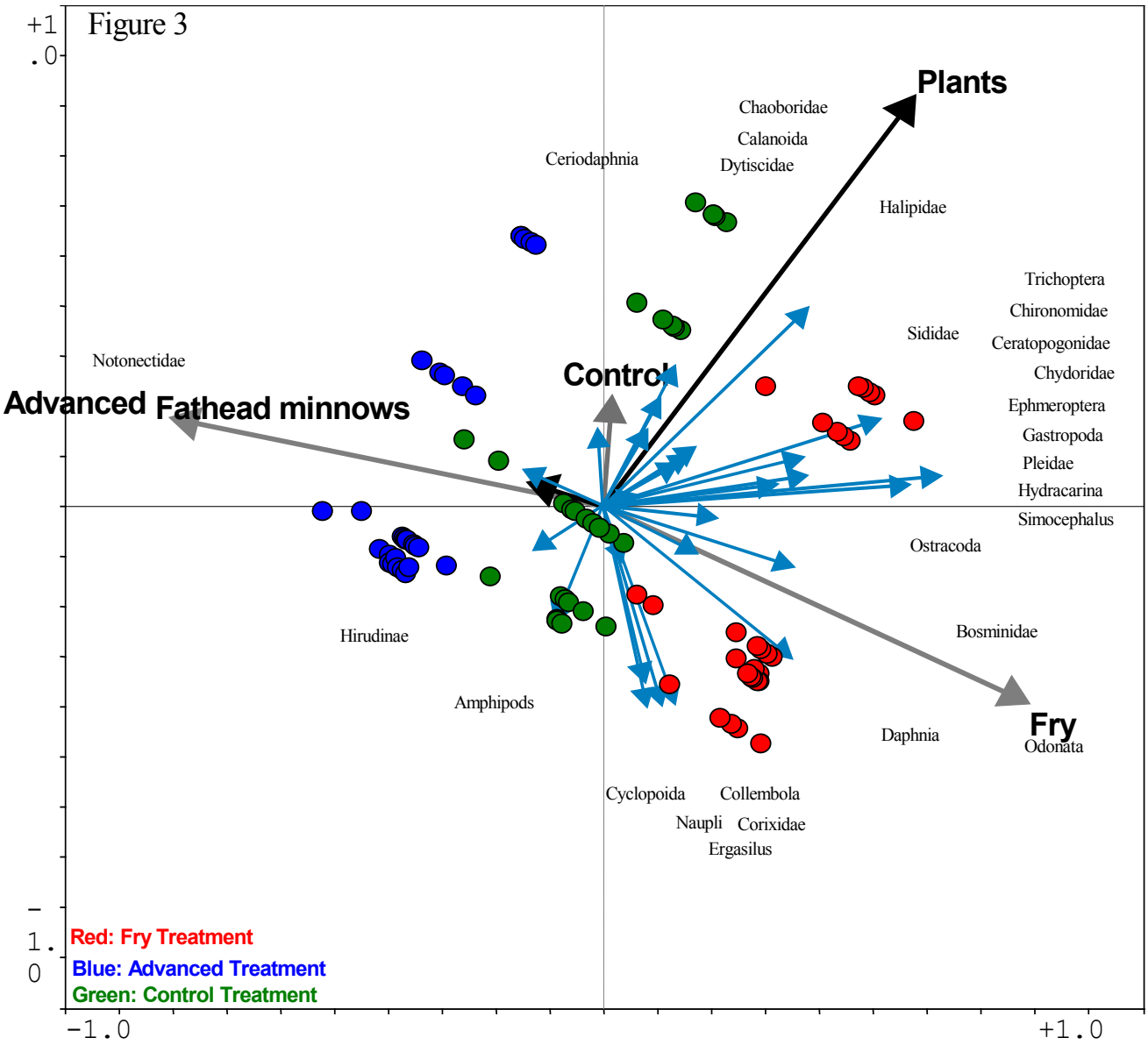


Figure 3 is an example of a partial redundancy analysis (P-RDA) ordination and how I am using this approach to evaluate my results. The explanatory variables in the RDA are the following: fathead minnows (biomass), plants (abundance), and treatments (fry, advanced, and control). The response variables are the invertebrate abundances. Three key points can be seen in the RDA. First, the majority of invertebrate taxa have a positive association with fry treatment wetlands, an over-all neutral association with control treatment wetlands, and a negative association with advanced treatment wetlands. Second, fathead minnows have a negative association with the fry treatment wetlands, a neutral association with the control treatment wetlands, and a positive association with the advanced treatment wetlands. Third, none of the treatments has a strong positive or negative association with plants.

The results from the first year of the study indicate that the biomanipulation in the fry treatment wetlands responded positively. The positive response can be seen in the decrease in fathead minnow biomass and the increase in cladoceran abundance in the fry treatment wetlands. The response in the advance treatment wetlands was negative, with decreased abundance of most invertebrate groups. The positive results in the fry treatment have potentially set the stage for

those wetlands to shift from being in a turbid water state to a clear water state during the second year of the study.