A Limnological Condition Assessment and Lake Management Plan Update for:

Whitmore Lake

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Executive Summary

Primary Goal of the Whitmore Lake Management Plan

The primary goal of Whitmore Lake Management Plan is to modify conditions within the lake to enhance species and habitat diversity and thereby stabilize the ecosystem by promoting the production of conservative species and inhibiting the production of those plants that are weedy or more opportunistic. The attainment of this goal is expected to foster conditions that will make Whitmore Lake more resilient to the rapid proliferation and domination of the aquatic ecosystem by invasive nuisance species. Success will also enhance recreational opportunities, including the fishery and the cultural utility of the resource. Any applied management strategy will focus on mitigating against the effects of cultural disturbance and be applied in a manner to minimize further disturbance of the ecosystem.

Proximal Management Goals

Nuisance Plant Production Management: The primary goal of the vegetation management plan is to mitigate against cultural and natural disturbances by modifying the quality of the Whitmore Lake flora through the prescriptive use of selective plant management agents and strategies. In recent years, the submersed flora of Whitmore Lake was dominated by the production of an opportunistic plant species, milfoil. Selective plant management agents are used to suppress the production of opportunistic and invasive species that are prone to form monocultures and suppress the production of preferred, conservative plant species.

Water Quality Management: Water quality management is typically focused on matters related to lake fertility, and the production of suspended algae (phytoplankton) and the fishery. Anecdotal evidence gathered from lake shore residents, indicate that water clarity has historically been very good in Whitmore Lake. Water clarity continues to be very good in Whitmore Lake suggesting that phytoplankton production in the lake is relatively low. Plant nutrient concentrations and water transparency readings taken in 2004 affirm that the water clarity is excellent and that the lake seems to support relatively little phytoplankton production. The proliferation and production of zebra mussel is likely to play a significant role as a determinant of water transparency, plant nutrient dynamics, and ultimately, fisheries production. The combination of relatively unproductive bottom sediments, low water column nutrient concentrations, and zebra mussel impacts suggest that fisheries production (total number of pounds produced) in Whitmore Lake may be limited by available nutrient resources. Typically, lake communities strive to limit nutrient (phosphorus) loading to as great a degree as possible; however, it appears that Whitmore Lake would not benefit from such programs which are designed to restrict the over production of phytoplankton. Although the water quality (clarity and phytoplankton production) of Whitmore Lake is not typical for a southeastern Michigan Lake the recommended water quality goals should be the same as other lakes in the region. Water quality conditions should be maintained or altered to favor the greatest degree of phytoplankton species diversity.

Blue green algae production can be increased, relative to other more desirable species, by the expansion and filter-feeding activities of zebra mussel colonies in the lake. Unfortunately,

AQUEST TIP

Disturbed Aquatic Ecosystems

Characteristics

- Noxious Plants and Algae
- Compromised recreational and utilitarian values
- Loss of aesthetic value
- Rapidly changing conditions, such as blooms of algae, plant monocultures, fish kills.

Common Disturbances

- Lake shore development,
- Watershed development,
- Pollution inputs (plant nutrients and sediments),
- Introduction of exotic organisms,
- Boating in shallow areas,
- Indiscriminant, non-ecologically based management practices.

technologies are only now being developed for the management of phytoplankton communities and these strategies are encumbered by the presence of zebra mussel. Whatever can be done to prevent the domination of the plankton community by blue green algae should be given high priority.

Other Considerations

The Whitmore Lake fishery is an important resource for Whitmore Lake and area anglers. The vegetation and water quality management programs are intended to benefit fisheries production and angling opportunities by improving the quality of the flora and mitigating against conditions that may lead to the proliferation of blue green algae. Swimming and boating represent other key resource uses. The primary goal of the Whitmore Lake Management Plan is consistent with the maintenance of conditions that will enhance opportunities for the pursuit of these recreational activities.

Summary Management Opinion

Primary Considerations

- Most major plant and fishery assessment indices for Whitmore Lake are considered to very good relative to other Michigan lakes. Biodiversity, "c" value, and species richness values are all high. The 2004 milfoil management program was very effective. Most plant indices were lower in the late summer of 2004, but are expected to recover completely in 2005.
- The distribution and density patterns of plants in Whitmore Lake are considered to be good. The proliferation of preferred plant species is expected in 2005.
- Total plantonic primary production appears to be low relative to other lakes. This limits the total production of the fishery; however, Whitmore Lake still supports an excellent fishery. There is an aabundance of suitable habitat to support a vibrant warm water fishery.
- Whitmore Lake is occasionally subject to blue green algae blooms. Recent studies and anecdotal evidence indicate that the domination of plankton communities by blue green algae may be a result of filter feeding zebra mussel.

Management Recommendations

- Milfoil is not expected to return at nusiacne levels in Whitmore Lake in 2005. Opportunistic species plant controls are not indicated for 2005.
- Plant community monitoring must be continued in 2005 to monitor trends in ecosystem development. The preferred species that dominated the lake in the late summer of 2004 are not expected to grow to nuisance levels; however, a permit application for nuisance weed control should be submitted to the Michigan DEQ in case discrete treatment is required in areas of the lake.
- Although total fisheries production may be limited by lake fertility, the quality of the fishery is considered to be excellent. No opportunistic, non-native, problem fish species were detected in the lake in 2004.

A SUMMARY OF CONDITIONS, 2003 - 2004

Results of the Aquest Aquatic Vegetation Community Assessment Method:

Aquatic vegetation grows in four distinct zones or Tiers in Whitmore Lake that roughly correspond with increasing depth. Vegetation community observation sites have been established in all four zones and are numbered to facilitate various analyses of plant community data by tier. The observation sites (AVOS) are depicted on Figure 1. By convention, the near shore areas are referred to as Tier 1 and are referenced by numbers ranging from 1 to 199 on Figure 1. Many of these areas are very shallow, sandy, and plant-free because of wind and wave action. The Tier 2 zone is characterized by deeper water and is generally more plant productive than the near-shore areas that are influenced by high energy waves and wind action. The Tier 2 observation sites are numbered from 200 to 299 on Figure 1. Tier 3 could be referred to as the "drop off" zone where the bottom slope is much greater that tier 1 and 2. The tier 3 observation sites are numbered from 300 to 399. Whitmore Lake also has vast areas, ranging in depth from 8' to 12', where slopes area very gradual and plant growth is significant. These areas are referenced as as tier 4 and the AVOS in that area area numbered from 400 to 499.

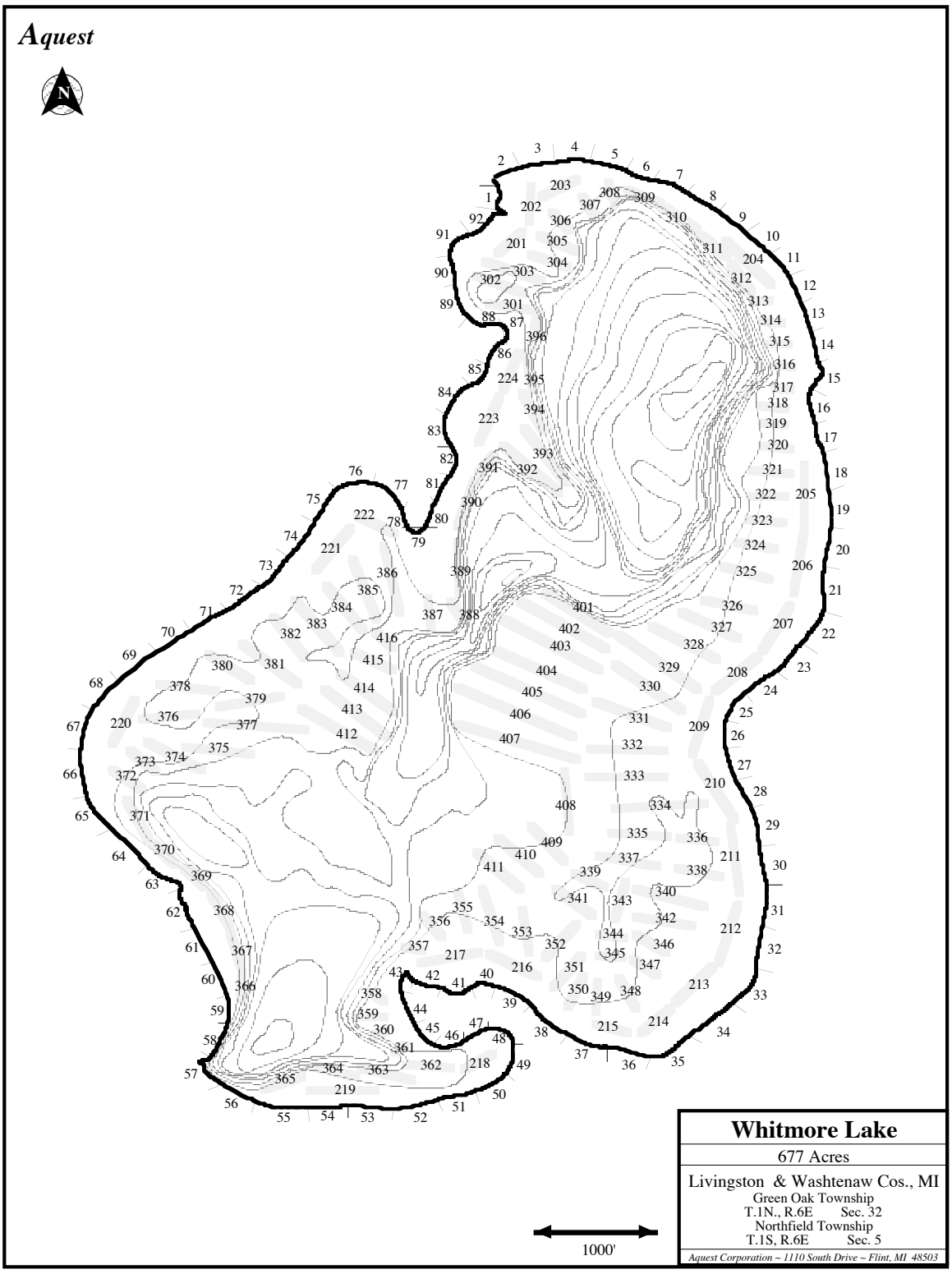
Observations were made at each of the observation sites depicted on Figure 1. Codes are used to aid data analysis. Each plant species is assigned a specific number which ordered according to the plant morphotype, "bushy", "leafy", "grassy", or "floating". The position of the plant in the water column, density and distribution of plants are also noted on the survey map. A code form with descriptors is included in the appendix attached to this document. These data were used to analyze the character of the plant community as follows:

Total % Vegetation Cover of Aquatic Vegetation Observation Sites:

Aquest Method Vegetation Surveys were performed in 2003 and in June and September 2004. The June 2004 plant survey was conducted as milfoil was dropping from the water column as a result of a fluridone aquatic herbicide application. Milfoil was found to inhabit nearly every conceivable habitat and depth zone in Whitmore Lake at the times of the 2003 and June 2004 surveys (82% and 87% respectively). When milfoil is considered, it seems that nearly all AVOS are capable of supporting rooted plant growth. However, it is estimated that less than 80% of the AVOS may be capable of supporting preferred species production since these species tend to not be as opportunistic as milfoil. The total number of vegetated AVOS's declined sharply from 2003 to late 2004 as a result of milfoil control efforts. The dense mats of milfoil that had formed in May 2004 dropped slowly into the water column, forming a barrier to other plant growth. This slow rate of decline is related to the low dose rate restrictions imposed by MI DEQ policy. Higher dose rates may have precipitated a more rapid decline of the milfoil mats and the subsequent release of desirable vegetation from milfoil shading; however, higher dose rates may have also imposed some inhibitory affects on the growth of these desirable species. It is expected that preferred species production will increase slightly in 2005. Table 1 illustrates the percentage of the total aquatic vegetation observation units found on Figure 1 that support aquatic vegetation for each of 5 years.

Table 1. The percent aquatic vegetation observation sites that supported aquatic vegetation according to observation sites depicted on Figure 1.

SURVEY DATE	% AVOS COVER
Sept 2003	98%
June 2004	97%
Sept 2004	77%


Aquest
N
1000'
Whitmore Lake
677 Acres
Livingston & Washtenaw Cos., MI
Green Oak Township
T.1N., R.6E Sec. 32
Northfield Township
T.1S, R.6E Sec. 5
Aquest Corporation ~ 1110 South Drive ~ Flint, MI 48503

Plant Species Richness (Total Species Present):

Twenty-four species have been found in Whitmore Lake since 2003; however, no more than 20 species have been found in any given year (Table 2.). The total number of species observed varied greatly from survey date to survey date. The greatest number of species, 20, was found in 2003 and the fewest number was found at the time of peak milfoil cover, June 2004. Preferred species production is expected to increase in Whitmore Lake in in 2005; however, the production of these species is not expected to reach nuisance levels. Curly leaf pondweed would normally be expected to grow to nuisance levels following a fluridone application of this type and timing but it was not very common in Whitmore Lake, and although it may increase in area cover, it is not expected to grow to nuisance levels in 2005. The production of this plant must be closely monitored. .

The species richness of tier 1 was the greatest of all the tiers on all of the survey dates, while species richness declined with increasing tier number. The production of milfoil in tier 4 was very dense in June 2004 and is believed to be the reason for the dramatic loss of species richness in these areas.

Table 2. Plant species observed in Whitmore Lake from 2003 to 2004.

	SPECIES NAMES		SURVEY DATE		
	COMMON NAME		Sept. 2003	June 2004	Sept. 2004
1	Water Shield	*Brasenia schreberi J.F. Gmel.*		√	
2	Coontail	*Ceratophyllum demersum L.*	√		√
3	Chara	*Chara sp.*	√	√	√
4	Elodea	*Elodea canadensis Michaux*		√	√
5	Eurasian Watermilfoil	*Myriophyllum spicatum L.*	√	√	
6	Green/Variable Milfoil	*Myriophyllum sp.*	√		
7	Naiad	*Najas sp.*			√
8	Spadderdock	*Nuphar sp.*	√	√	
9	Waterlily	*Nymphaea sp.*	√	√	√
10	Broad Leaf Pondweed	*Potamogeton amplifolius Tuckerman*	√	√	√
11	Curly Leaf Pondweed	*Potamogeton crispus L*	√		
12	Variable Pondweed	*Potamogeton graminius L.*	√		√
13	Illinois Pondweed	*Potamogetion illinoensis Morong*	√	√	
14	Floating Leaf Pondweed	*Potamogeton natans L.*	√		√
15	White Stem Pondweed	*Potamogeton praelongus Wulfen*	√		
16	Richardsons Pondweed	*Potamogeton richardsonii (Benn.) Tydb.*	√		
17	Robbins Pondweed	*Potamogeton robbinsii Oakes*	√	√	√
18	Thin Leaf Pondweed	*Potamogeton sp.*	√	√	√
19	Flat Stem Pondweed	*Potamogeton zosteriformis Fern.*	√	√	√
20	Duck Potato	*Sagittaria sp.*			√
21	Sago Pondweed	*Stuckenia pectinatus L.*	√	√	√
22	Common Bladderwort	*Utricularia vulgaris L.*	√		
23	Wild Celery	*Vallisneria americana Michaux*	√		√
24	Water Star Grass	*Zosterella dubia (Jacq.) Small*	√		√
	TOTAL SPECIES NUMBER		20	12	15

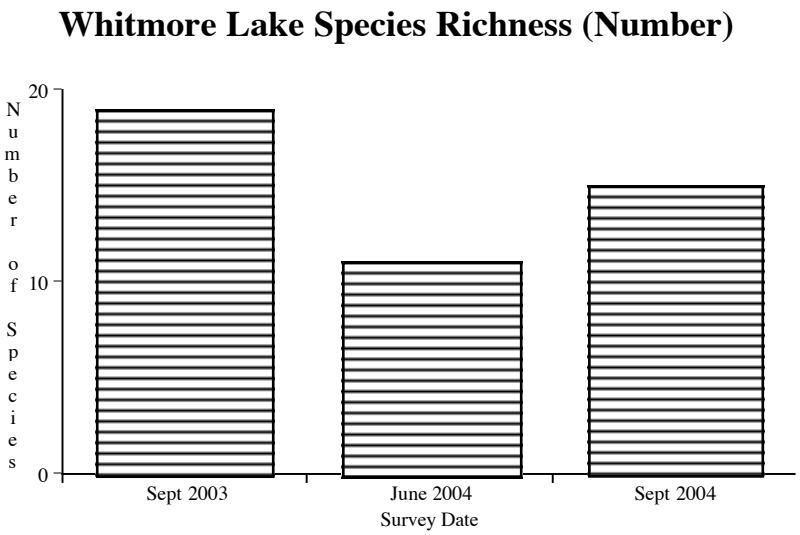


Figure 2. Whitmore Lake plant species richness (total number of plant species).

Plant Community Biodiversity:

The relative biodiversity of Whitmore Lake was extremely high in 2003 but declined sharply by September 2004 even when target nuisance species (milfoil) are factored into the consideration (Figure 3.). It is important to note that the total number of species present in September, 2004 was greater than observed in June, 2004; however, many of the species were found at a very low number of AVOS. In the absence of milfoil, many of the species that were observed during the September 2004 survey are expected to spread to more AVOS's and an increase in biodiversity is expected in 2005.

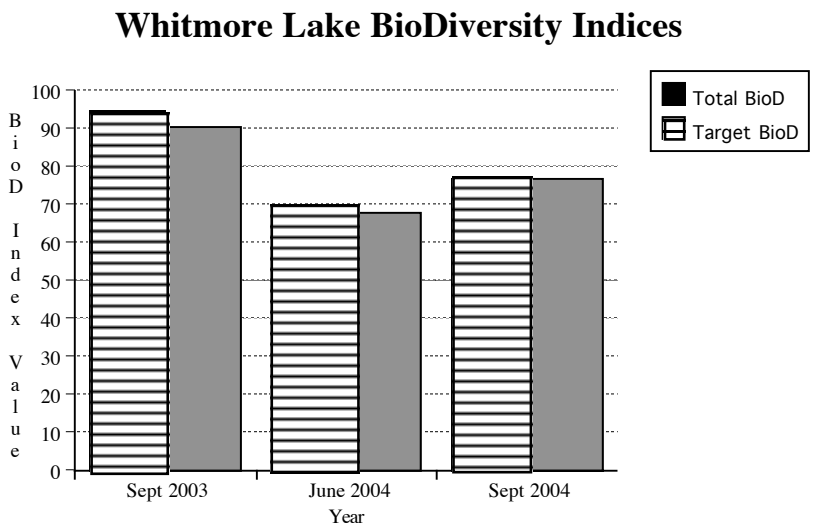


Figure 3. The total biodiversity (all plant species present) and the biodiversity of Whitmore Lake when milfoil and curly leaf pondweed are not factored into the calculation (target biodiversity).

Plant Community Quality:

"C" Values:

Submersed plant communities that are dominated by conservative, rather than opportunistic species are generally considered to be more desirable by persons who use lakes for a variety of purposes. Lakes that are dominated by opportunistic species are generally considered to be "too weedy". A "c" value, ranging from 1 to 10, is assigned to each species to describe how likely a plant is to be found in either disturbed or conservative (stable) ecosystems. Opportunistic plants, that are more tolerant of cultural disturbance are usually considered to be the worst weeds and are assigned lower "c" values. Plant species found in stable, less disturbed lakes are not usually considered to be "weedy" and are assigned higher values. The mean "c" value can be used to roughly estimate the quality of the lake flora. The quality of the plant community in Whitmore Lake in terms of "c" value has generally improved as more conservative, preferred species have become more common in the lake. Mean "C" values are considered to be very good, relative to other lakes in the region. Higher "c" values suggest that the Whitmore Lake ecosystem is also more stable than other regional lakes. The mean "c" value in Whitmore Lake is expected to increase in 2005 as broad leaf pondweed is expected to cover more area than it did in 2004.

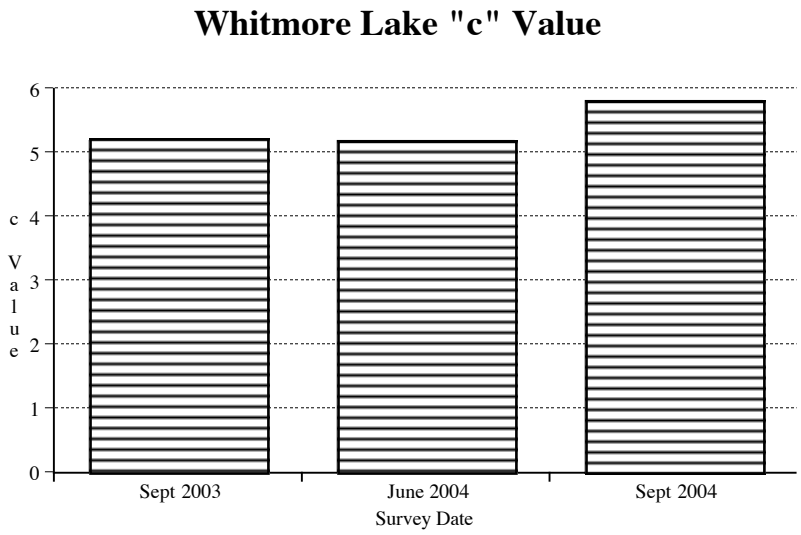


Figure 4. Whitmore Lake macroflora mean annual "c" values a
AVOS surveyed in 2003 and 2004.

Plant Morphotypes:

The variety of leaf type and morphometry of the plant plant species found in the plant community can also be used as a measure of plant community quality. Studies have shown that fisheries production and quality is greater where plant communities are considered diverse in terms of leaf type and plant morphology. Despite the overwhelming presence of milfoil, the pondweeds and their "leafy" leaf morphology dominate Whitmore Lake. The "bushy" leaf type, as represented by milfoil, peaked in June 2004 and then dropped to the lowest level by late 2004 as a result of the intended milfoil decline. Leafy species, such as pondweeds expected to become even more common in Whitmore Lake in 2005 and it is expected that the leafy plant types will become even more dominant. It is also expected that "grassy plants"such as wild celery and the submersed form of arrowhead will also increase in the absence of milfoil.

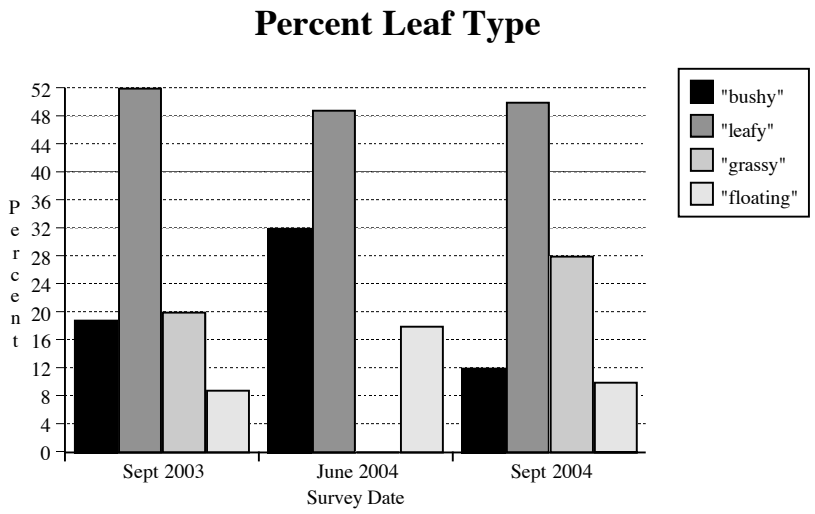


Figure 5a. Submersed macrophyte community morphotype as percent of total leaf type at AVOS's ("bushy", "leafy", "grassy", "floating" types) established for Whitmore Lake.

Variability in leaf type may be another important plant community characteristic to consider from the perspective of fisheries and wildlife habitat values. Figure 5b presents morphotype data as a standard deviation of a mean value as a means to express variability in leaf type. Presumably, the greater the variation the better the plant community for the support of fisheries and wildlife values.

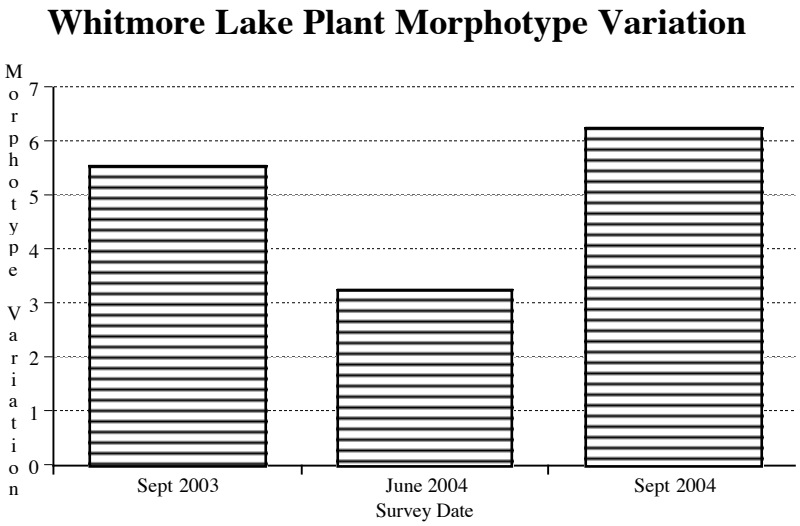


Figure 5b. Whitmore Lake submersed macrophyte community morphotype deviation ("bushy", "leafy", "grassy", "floating" types) expressed as the standard variation of the mean morphotype values found at the Whitmore Lake AVOS sites for each survey date.

Mean deviation or variation in leaf type was greater in Whitmore Lake following the milfoil control program with a peak value being recorded in September 2004. The domination of the lake by milfoil seems to be responsible for the lower deviation value recorded for June 2004.

Plant Distribution and Density:

The quality of the plant community in Whitmore Lake is also considered from the perspective of density and distribution. Density and Distribution are subjective values that are used to describe how much vegetation is observed per unit area and how it distributed within the AVOS. Field data are evaluated as follows:

Density "a" Rare: The plant species has been observed; however, it is unlikely that the plant could be found again if the observer were to return to the observation site.

Density "b" Present: This designation is an artifact from methods used in the early 1990's and should not be used. It is listed here; however, because the term is still used by the MI DEQ. The "b" value is used instead of the "c-" value that is used in the field. This value is used to describe plants that could be found if the observer were to return the observation site, but the plant is not common or dominant in the observation zone.

Density "c" Common: This term is used to describe plant species that are common throughout the observation site.

Density "d" Dense: This term is used to describe the production of a species or perhaps several species that totally dominate the observation site where they form dense low-growing meadows or impenetrable surface mats of vegetation.

Distribution "s" Scattered: The plant is observed to be randomly scattered around the observation site, usually as a single plant or small clump of plants comprised of several stems.

Distribution "sp" Scattered Patches: The plant is observed as clumps of several plants scattered around the observation site.

Distribution "p" Patchy: The plant is observed to cover large patches or areas within the observation site; however, the plant does not cover more than 50% of the total area.

Distribution "cp" Contiguous Patches: This term is used to describe plant growth that is usually dense and where places that are not occupied by the described species appear to be patches within the mass of vegetation produced by the described species.

Density:

It is generally preferred that most plant species be found at "b" or "c" level densities which indicate that most of the plant species present in the lake are capable of inhabiting many areas of the lake and that species richness numbers are not merely inflated by rare species confined to narrowly defined habitats. The mean density of plants in Whitmore Lake varied tremendously from 2003 to 2004 (Figure 6). The overwhelming predominance of milfoil resulted in dense plant growth at most of the AVOS's in 2003 and June 2004. The decline of milfoil resulted in a relative increase in "c" density values at most of the AVOS's and improved conditions. Low-growing, meadow-forming plants, such as Chara may expand in area cover (and AVOS number) in 2005 and a resulting increase in "d" density value may occur. This; however, is considered to still be acceptable and is a preferred outcome.

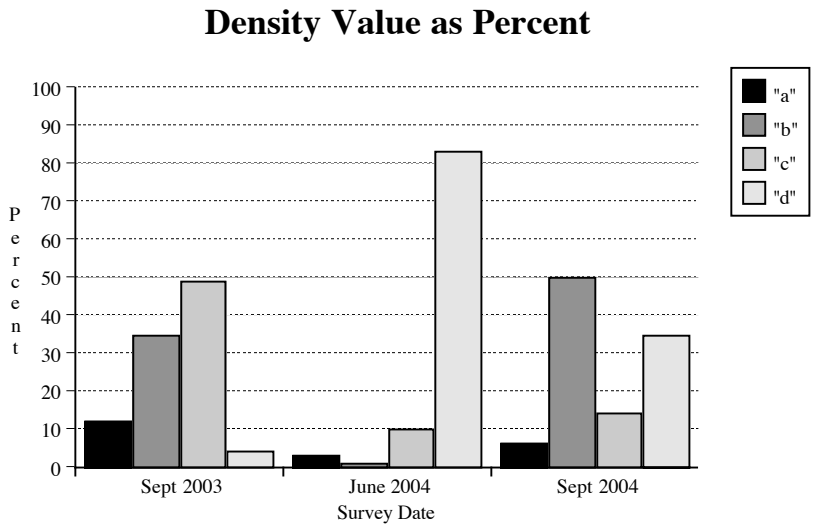


Figure 6. The mean density value expressed as percent of AVOS's, of the Whitmore Lake submersed flora in 1990, 1995, 2001, 2002, and 2004.

Distribution:

Open space is generally considered to be a desirable feature in plant communities because it can contribute to habitat complexity by creating more "edge". Plant distributions must be considered within the context of plant height and the diversity of leaf type. Scattered "s" and scattered patch "sp" distributions are generally considered to be the most desirable distribution patterns for recreation and fisheries and wildlife considerations. Contiguous patches "cp" of vegetation are not necessarily negative if the plant are forming dense meadows of low-growing vegetation that carpets the bottom of the lake. Contiguous patch distribution is extremely undesirable when the plants are growing at the water surface. The "p" or patchy distribution patterns dominated Whitmore Lake in June 2004 because milfoil was generally found growing in that pattern (Figure 7). The preferred plants in Whitmore Lake appear to adopt a more scattered distribution pattern. As greater area is available for preferred plant species production as a result of the 2004 fluridone application, it is expected that more plants will be observed to grow in scattered patches "sp" or even patchy "p" distribution patterns. The patchy patterns are preferred for fisheries and wildlife support.

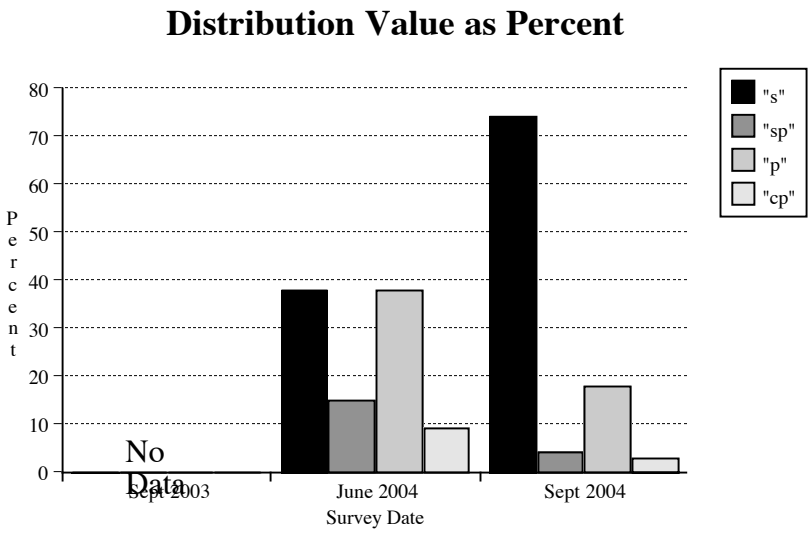


Figure 7. The mean distribution value of Whitmore Lake submersed flora at AVOS's surveyed in 2003 and 2004.

Selected Plant Species and Other Considerations

Nuisance Plant Production:

Nuisance plant production in Whitmore has been rare, according to reports from lake side residents and persons who have frequented the lake for decades. Milfoil may have been present in the lake for a long time; however, it appeared to become a significant nuisance in Whitmore Lake in 2002. Aquest Corp. discovered the presence of a hybrid milfoil in Michigan in 2003. Studies are being conducted to identify the genotype of the milfoil found in Whitmore Lake; however, the milfoil plants observed in Whitmore Lake do not appear to be hybrids. However, hybrids may have been present in Whitmore Lake and are known to be more resistant to herbicide treatments and may be capable of more rapid recovery than the Eurasian type that initially invaded Michigan inland lakes. There are also some concerns regarding "native" Michigan species that are demonstrating an increasing propensity to grow at nuisance levels in Michigan inland lakes.

The 2003 fluridone application appears to have provided adequate control of milfoil and should result in an increase in all major quality indices. Continued monitoring is required to adequately assess the results of the 2004 management program.

Milfoil:

Milfoil dominated the flora of Whitmore Lake since 2003 and early 2004 in terms of presence at the greatest number of aquatic vegetation observation sites and height in the water column. The emergence of a milfoil hybrid and uncertainty regarding the recovery of these genotypes make it difficult to predict the longer term outcomes of the 2004 program. It is expected; however, that milfoil production will not constitute a significant nuisance in 2005. Contact herbicides can be used selectively and effectively for milfoil control. Any contact herbicide applications need to be implemented in all parts of the lake where milfoil is present prior to the Fourth of July Holiday.

Curly Leaf Pondweed:

The production of curly leaf pondweed can be as noxious as milfoil. The long-term control of curly leaf pondweed is virtually impossible unless fluridone is used in narrowly prescribed ways. This plant seems to "explode" in May and June and then, naturally collapses in early July. It has not been found at nuisance levels in Whitmore Lake. If it does grow to observable levels, contact herbicides should be applied at species selective rates protect before preferred plant species are suppressed by its production in the late spring and early summer.

Broad Leaf Pondweed:

The pondweeds (except the exotic curly leaf pondweed) are generally considered to be preferred species in Michigan inland lakes. Most pondweeds are considered to be conservative species with "c" values exceeding 5. They do not typically form large monotypic plant stands, grow at high densities, or contiguous distribution patterns as do many of the opportunistic, and invasive species. Broad leaf pondweed is usually considered to be a conservative species with a "c" value ranking of 7. However, broad leaf pondweed has been found to spread rapidly in some lakes where milfoil has been effectively suppressed. In some cases broad leaf pondweed has appeared to be far more invasive than expected and has formed large monotypic meadows where it has eliminated other plant species production. This growth pattern is inconsistent with the goals of the Whitmore Lake management plan. Pondweed species are known to freely hybridize and is quite possible that a broad leaf pondweed hybrid or genotype is emerging as a new invasive species in Michigan lakes. Broad leaf pondweed was observed at 63% of all AVOS's in Whitmore Lake in September 2004. The broad leaf pondweed production must be closely monitored in Whitmore Lake and corrective actions would be indicated if it is found to diminish biodiversity in the Whitmore Lake flora.

Nuisance Algae Production:

The bio-geochemistry of Whitmore Lake does not appear to be predisposed to the production high phytoplankton concentrations. Spring-time and mid-summer phosphorus data were at non-detect levels (less than 6 ppb) indicating relatively low plant fertility in the lake. Consequently, the total production of fish would be expected to be low, relative to other southeastern Michigan Lakes, when considered on a fish per unit area basis. Unfortunately, the production of toxic blue green algae (Cyanobacteria) is enhanced by the presence of zebra mussel at any phosphorus levels. These algae represent a heath risk for swimmers and those who may be exposed to aerosols from irrigation systems that use water containing these noxious algae. Large-scale blue green algae blooms were not observed in 2003 or 2004; however, the presence of zebra mussel suggest that bloom conditions could easily be formed.. Every effort must be prevent the domination of the Whitmore lake planktonic flora from being dominated by these noxious organisms although there are currently, now proven means available to control blue green algae.

AQUEST TIP:

Blue Green Algae Concerns

Blue green algae are becoming an important issue for many riparian property owners. Recent studies have revealed disturbing findings regarding the toxicology of substances made and released into the water by these nuisance algae. These substances can seriously threaten the public health and poison pets and wildlife. Studies are in progress related to the potential risks that the lake users may encounter when exposed to blue green algae blooms. Riparian property owners are urged to not panic, but take some precautions. Until these studies are completed, it is recommended that persons not swim in waters where blue green algae blooms are evident. These conditions would include blooms where it appears that green latex paint has been spilled on the water, or that the water in enclosed bays is covered by an oil slick. Blue green algae blooms are usually temporal events and may disappear as rapidly as they appear. Riparian property owners should learn to recognize blooms and act accordingly.

Water Quality Management

Whitmore Lake is unusual for a southeastern Michigan Lake because water column essential plant nutrient levels are very low and water clarity is very high. Excessive nutrient loading does not appear to be a significant problem in Whitmore Lake at this time. Total phosphorus levels were determined to be below detection levels <6 ppb when sampled in June and September. Acceptable levels are considered to range as high as 30 ppb for southeastern Michigan Lakes. These low nutrient levels certainly limit phytoplankton growth and contribute to excellent water clarity, but they also may limit fisheries production. Never-the-less, the presence of zebra mussel demands that the lake continue to be protected from any culturally derived nutrient inputs (runoff from construction sites, hard surfaces such as roofs, roads and driveways, or lawn fertilization) because any plant nutrients could be channeled into the production of blue green algae by the feeding activities of the mussel.

According to lake residents, the clarity of Whitmore Lake has always been good. Secchi Disk Transparency data is presented for 2004 in Figure 8. Values never dipped below 3.5 meters which is an excellent value for a lake in southeastern Michigan. Values did trend downward from approximately 7 meters to 3.5 meters in September. Typically, blue green algae bloom in the late summer months and although such a bloom was not conspicuous, it is possible that a slight increase in blue green algal biomass may have been responsible for the declining Secchi Disk values. One of the consequences of removing a large milfoil infestation is that much of the bottom of a lake can be exposed to wind and wave action. It is also conceivable that the temporary lack of bottom cover could have been responsible for declining Secchi Disk readings. It is important to note that even though transparency values declined in the late summer, even the lowest reading is considered to be excellent. Water clarity was much better than expected and is not currently a matter of concern.

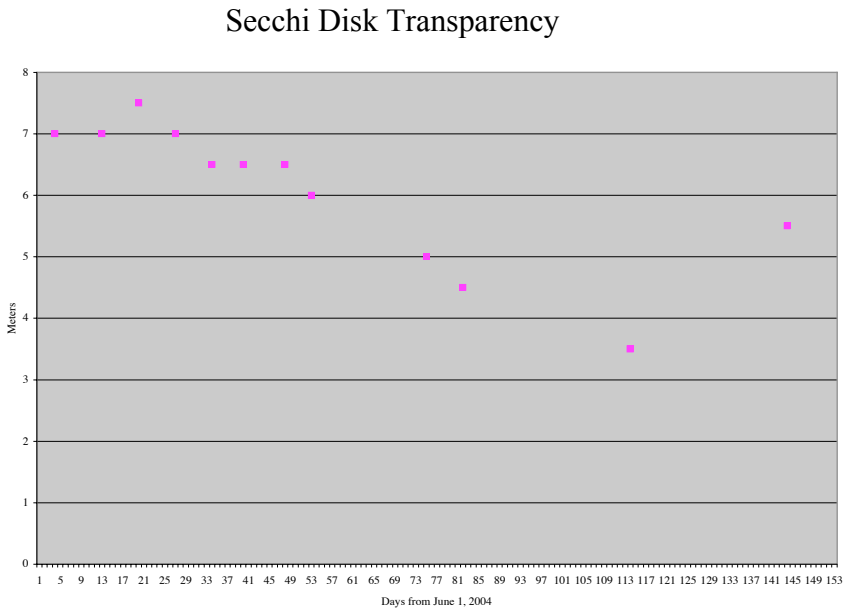


Figure 8. Secchi Disk Transparency Values in meters for Whitmore Lake, 2004.

SEAS, Inc. Fishery Assessment

Fishery Assessment Purpose and Methods

The purpose of the fishery habitat assessment is to evaluate the quality and location of critical fish spawning and nursery habitat within Whitmore Lake. The fishery of Whitmore Lake is an important natural and recreational resource in a highly populated region and, therefore, requires careful and sound fishery management. To assemble the necessary information for fishery management recommendations, SEAS aquatic biologist conducted assessments of historical data, angler interviews and field inspection and remote evaluation (maps) of critical fishery habitat. Field inspection of critical habitats was conducted from the boat during the time of the spring aquatic vegetation assessment.

Fishery Survey

The Michigan Department of Natural Resources Fisheries Division has periodically conducted intensive fishery surveys of Whitmore Lake. A 1992 fish survey catch indicated that Whitmore Lake supported a diverse warm water fish population. The trap net catch indicated the presence of a healthy gamefish population (Towns, 1993). Gamefish comprised 97% of the trap net catch by number and over 64% of the catch by weight. Carp comprised much of the remaining catch biomass (26%). Bowfin, also referred to as dogfish, made up most of the remainder of the weight in the trap net catch (9%). A boomshocker was used primarily to evaluate species diversity, capture small gamefish for scale samples, and capture bass and carp for contaminant analysis. Fifteen species were captured with the boomshocker, most of which were also taken with trap nets, and include tiger musky, mud pickerel, spotfin shiner, and bluntnose minnow. The most recent fishery survey was conducted by the MDNR in April 1998 (Table 1). The species collected and fishery composition data from that survey were found to be similar to other surveys. Rock bass, brown bullhead and bluegill sunfish were the most abundant species collected. A total of twenty seven species of fish have been collected during the past surveys. No rare or endangered species were found in the lake.

Table 3. Number and weight of fish species captured during Michigan Department of Natural REsources trap net survey of Whitmore Lake in April, 1998.

Species	No. Caught	Lbs. Caught	Average Length (Inches)
Black crappie	86	29.83	8.3
Bluegill	536	161.65	6.2
Bowfin	8	29.18	21.5
Brown bullhead	137	113.58	12
White sucker	26	87.22	20.3
Golden shiner	3	0.46	7.8
Hybrid sunfish	3	0.84	7.2
Largemouth bass	99	111.81	12.6
Northern pike	6	24.69	26
Pumpkinseed	25	5.35	6.3
Redear sunfish	9	1.9	6.7
Rock bass	141	33.56	6.6
Yellow perch	2	0.43	8
Yellow bullhead	10	5.35	10.4
Total	1091	605.85	

Fish Stocking

MDNR records indicate that over nine hundred thousand fry have been planted in Whitmore Lake. These records include numbers for two species, redear sunfish and tiger muskellunge. Seven hundred thousand fish were planted in during the 1990's (Table 2) until the MDNR fish stocking program was was discontinued toward the end of the decade. The tiger muskellunge planted during the 1980's and 1990's provided anglers with the opportunity to catch a trophy sized game fish. Redear sunfish continue to attract anglers to Whitmore Lake.

Table 4. Number of fish planted in Whitmore Lake by Michigan Department of Natural Resources (MDNR) from 1979 to present.

Species	1979	1980's	1990's	2000-2005	Totals
Redear Sunfish	0	0	7,500	0	7,500
Tiger Muskellunge	0	81,300	2,000	0	83,300

Recreational Fishing Experience

Despite the relatively low fish production potential in Whitmore Lake, the fishery is still considered to be of very high quality. MDNR fish biologist Jeff Braunschiedel considers Whitmore Lake to be an excellent recreational fishery (Personal communication, 2004) and Whitmore Lake is known as one of the best fishing lakes in the state. Bluegill, crappie, smallmouth bass, largemouth bass, northern pike and walleyes are the most common targets of anglers. Crappies, bluegill and redear sunfish are called panfish as they are excellent table fare. Conversations with anglers conducted during the critical fish spawning and nursery habitat survey indicated that black crappie and redear sunfish were the targeted species. Positive angler experiences are closely assoicated with the size of the fish that are caught and the size of fish in Whitmore Lake is very good.

Critical Fish Spawning and Nursury Habitat Assessment

The Whitmore Lake basin has a rather deep north-south trench with the deepest point in the northern end (69 feet). There are extensive shoals on either side of this trench; as a result, over half of the lake is less than 10 feet deep. Development in the form of cottages, permanent homes, beaches, and roads is very extensive. Very little "natural" shoreline remains intact.

Basin substrates consist primarily of sand from the shoreline to a depth of 10 feet. Fibrous peat makes up the lake bottom in the 10 to 20 foot depth range, and the deep basin areas consist mostly of pulpy peat.

Assessment of critical spawning and nursery habitat was conducted using field observation, MDNR Lake Maps (showing bottom type) and research on the life history strategies of fish known to inhabit the lake. Critical spawning and nursery habitat parameters assessed include 1) spawning substrate type; 2) spawning substrate diversity; 3) depth; 4) relative abundance of spawning habitat and 5) shoreline development. Nursery habitat parameters included 1) observed use, 2) connectedness to

lake; 3) vegetation type and 4) shoreline development. In determining critical spawning and nursery habitat we assess both individual and combined value of the habitat parameters. Because the assessment occurs over the span of one day during the spawning season, the survey can only be considered a snapshot of the actual utilization on the day of the observation. Nevertheless, the potential for habitat to serve spawning and nursery functions of fish can be considered accurate within the limits of methods used to assess habitat. If a threatened or endangered species is present, its habitat will be automatically deemed critical.

Table 5. An evaluation of critical fish spawning and nursury habitat parameters in Whitmore Lake, June 2004.

Critical Spawning Habitat Parameters and Score

Spawning Substrate	***Score***
Sand Gravel Complex	5
Sand Marl Complex	4
Sand Silt Complex	3
Vegetation	3
Rock Reef	3
Cobble Shoal	3
Drowned Tree / Stumps	3
Root Wad / Undercut Bank	3
Firm Clay	2
Muck/Unconsolidated Organics	0

Spawning Substrate Diversity	***Score***
4 Types<	6
3 Types	5
2 Types	4
1 Type	3

Depth	***Score***
0 – 6 Feet	3
7 – 12 Feet	2
12 Feet <	1

Use	***Score***
High	6
Medium	5
Low	4
None	0

Relative Abundance	***Score***
Low	5
Medium	4
High	3

Shoreline	***Score***
Un-Modified	2
Modified	1

Nursery Habitat Parameters and Score

Use	***Score***
Active Observed	2
No Use Observed	0

Depth	***Score***
0 – 3 Feet	4
4 – 6 Feet	3
7 Feet <	1

Connectedness to Lake	***Score***
Directly Connected / In lake	6
Many Diffuse Connections	5
More Than Discrete Connections	4
> Three Discrete Connections	2

Vegetation Type	***Score***
Floating Leaved/Emergent / Submergent Complex	6
Floating Leaved/Submergent Complex	5
Floating Leaved/Emergent Complex	5
Emergent/ Submergent Complex	5
Floating Leaved	3
Submergent	3
Emergent	3
None	0

Shoreline	***Score***
Un-Modified	2
Modified	1

A bluegreen algae bloom slightly obscured visual observation of habitat in some areas during the June critical spawning and nursery habitat survey. Spawning habitat for fish species, such as sunfish and bass, that utilize sand and gravel substrates for nests was very abundant in the littoral areas (Figure 9). A critical spawning area was observed along the northeast bay of the lake, near the public boat launch. In this area bottom substrate was comprised of a mixture of sand and fine gravel. Two areas (shown in red) were being actively used by sunfish. A largemouth bass was also observed in slightly deeper water hovering over a bowl shaped nest partially obscured by sparse stands of emergent vegetation. The spawning areas were in close proximity to high quality nursery habitat located among the easternmost shore of the bay. The nursery habitat in this area consisted of a diverse community of submergent vegetation and was being actively utilized by young of the year bass, and sunfish. A second critical spawning and nursery habitat area was identified in the southwest corner of the lake. Although no active use was observed the proximity of ample spawning substrate to high quality nursery area with little shoreline development is unique to the lake. The nursery area contains an abundant and diverse submergent plant community as well as floating leafed vegetation. This area would be prime spawning habitat for northern pike, yellow perch and other species that spawn over vegetation. Overall, Whitmore Lake has large areas of spawning habitat suitable for the variety of species known to inhabit the lake in contrast nursery habitat in littoral areas is patchy in distribution and varies in quality. Efforts to prevent shoreline modification in areas adjacent high quality nursery habitat should be implemented.

SEAS TIP

The Importance of Fish Spawning and Nursury Habitat

There are many factors that affect the recreational fisheries including, angling pressure, other recreational uses, climate, competition, primary productivity, water quality and resource management decisions. Quality and quantity of spawning and nursery habitat are two fundamental components of fish life history and can determine the survival of a species in a given environment. In simple terms, naturally sustaining fish populations cannot occur without a place to spawn. In addition, if spawning success is good but mortality of fry is high (due to lack of nursery habitat) then the number of adults added to the existing population by that year class will be reduced. In some species of fish mortality within the first 100 days of life can be as high as 99%. The high mortality of the early life stage is typically referred to as the bottleneck in population potential.

Spawning habitat consists of the physical structure selected by adult fish for egg deposition and fertilization. Nursery habitat consists of the area that provides the right food, shelter and optimal temperature for survival and accelerated growth of fry and young-of-the-year (YOY). In impoundments where water levels are manipulated it is important to know where these critical habitats are and what the possible effects of water level manipulation may be upon them.

Figure 9. Critical spawning and nursery habitats observed in Whitmore Lake in June 2004.