####  The Aquatic Plant Community

#### in the Tri-Lakes, Adams County

**2000**

**I. INTRODUCTION**

A study of the aquatic macrophytes (plants) in Tri-Lakes was conducted during July 2000 by Water Resources staff of the West Central Region - Department of Natural Resources (DNR) and Fish and Habitat staff of the Central Wisconsin Basin – DNR: Jason Folstad, Josh Maiers, Chris Sangor, and Josh Sanger. This was the first quantitative vegetation study of the Tri-Lakes that was conducted by the DNR.

A study of the diversity, density, and distribution of aquatic plants is an essential component of understanding a body of water due to the important ecological role of aquatic vegetation and the ability of the vegetation to characterize the water quality (Dennison et al. 1993).

 **Ecological Role:** All other life depends on the plant life (including algae) - the beginning of the food chain. Aquatic plants provide food and shelter for fish, wildlife, and the invertebrates that in turn provide food for other organisms. Plants improve water quality, protect shorelines and river bottoms, add to the aesthetic quality of the lake and impact recreation.

 **Characterize Water Quality:** Aquatic plants serve as indicators of water quality because of their sensitivity to water quality parameters, such as water clarity and nutrient levels (Dennison et. al. 1993).

The present study will provide information that is important for effective management: fish habitat improvement, protection of sensitive wildlife areas, aquatic plant management, and water resource regulations. The baseline data that it provides will be compared to future macrophyte inventories and offer insight into any changes occurring.

 **Background and History:** The Tri-Lakes are a series of impoundments on Fourteenmile and Spring Branch Creeks, in Adams County, WI. The Tri-Lakes are composed of four lakes. The upstream lakes are Upper Camelot Lake, (191-acres) which impounds Spring Branch Creek and Lower Camelot Lake, (260-acres) which impounds Fourteenmile Creek. A channel connects Upper Camelot Lake and Lower Camelot Lake. Sherwood Lake is in the middle (250-acres) and impounds the confluence of Spring Branch and Fourteenmile Creeks. The downstream lake is Arrowhead Lake (295-acres) and impounds Fourteenmile Creek. The Tri-Lakes watershed drains 54,935 acres of land.

 **Aquatic Plant Management**

Several methods have been employed on the Tri-Lakes for the management of aquatic plant growth.

1. WINTER DRAWDOWN

Although the purpose of the drawdowns over the winter is not expressly for the control of aquatic plants, the freezing of the sediments will impact some species.

1. MECHANICAL HARVESTING

Each of the Tri-Lakes impoundments has a mechanical harvester that operates most of the summer.

1. AQUATIC HERBICIDES

Aquatic herbicides have been applied to Camelot and Sherwood Lakes since 1970 and to Arrowhead Lake since 1981 (Tables 1, 2, 3).

Table 1. Aquatic Herbicides Applied to Camelot Lake, 1970-2000.

**Table 2. Aquatic Herbicides Applied to Sherwood Lake, 1970-2000.**

**Table 3. Aquatic Herbicides Applied to Arrowhead Lake, 1970-**

 **2000.**

Large amounts of copper sulfate have been added to the Tri-Lakes: 7967 pounds of copper sulfate in Lake Camelot (Table 1),

10,178 pounds of copper sulfate in Lake Sherwood (Table 2),

6920 pounds of copper sulfate in Lake Arrowhead (Table 3).

Copper is an element and does not biodegrade any further. The combination of copper sulfate and Cutrine applied over the years has added 2018 pounds of the element copper to the sediments of Camelot Lake (Table 1), 2579 pounds of the element copper to the sediments of Sherwood Lake (Table 2) and 1754 pounds of the element copper to the sediments of Arrowhead Lake (Table 3).

Silvex, which is the compound 2, 4, 5-TP, was added to Camelot and Sherwood Lakes. This chemical is no longer approved for aquatic application.

Hydrothol, which has been implicated in damage to young fish, was applied to Arrowhead Lake in 1984, to Camelot Lake in 1976-77 and 1985, to Sherwood Lake in 1977-81 and 1984.

**II.METHODS**

**Field Methods**

The study design was based primarily on the rake-sampling method developed by Jessen and Lound (1962), using stratified random placement of the transect lines. The shoreline of each lake was divided into a predetermined number of equal segments and a transect, perpendicular to the shoreline, was randomly placed within each segment, using a random numbers table. 30 transects were placed on Arrowhead Lake; 36 transects were placed on Sherwood Lake; 20 transects were placed on Upper Camelot Lake; 20 transects were placed on Lower Camelot Lake; 10 transects were placed on the Camelot Lake channel.

One sampling site was randomly located in each depth zone (0-1.5 ft., 1.5-5 ft., 5-10ft and 10-20ft.) along each transect. Using a long-handled, steel-thatching rake, four rake samples were taken at each sampling site. The four samples were taken from each quarter of a 6-foot diameter quadrat. The aquatic plant species that were present on each rake sample were recorded. Each species was given a density rating (0-5) based on the number of rake samples on which it was present at each sampling site. (A rating of 1 indicates that a species was present on one rake sample...a rating of 4 indicates that it was present on all four rake samples and a rating of 5 indicates that it was abundantly present on all rake samples at that sampling site.) The sediment type at each sampling site was also recorded.

Visual inspection and periodic samples were taken between transect lines in order to record the presence of any species that did not occur at the sampling sites. Specimens of all plant species present were collected and saved in a cooler for later preparation of voucher specimens. Nomenclature was according to Gleason and Cronquist (1991).

The type of shoreline cover was recorded at each transect. A section of shoreline, 50 feet on either side of the transect intercept with the shore and 30 feet back from the shore, was evaluated. The percentage of each cover type within this 100' x 30' rectangle was visually estimated and verified by a second researcher.

## Data Analysis

The percent frequency of each species was calculated (number of sampling sites at which it occurred / total number of sampling sites) (Appendix I-V). Relative frequency was calculated based on the number of occurrences of a species relative to total occurrence of all species (Appendix I-V). The mean density was calculated for each species (sum of a species' density ratings / number of sampling sites) (Appendix VI-X). Relative density was calculated based on a species density relative to total plant densities. A "mean density where present" was calculated for each species (sum of a species' density ratings / number of sampling sites at which the species occurred) (Appendix VI-X). The relative frequency and relative density was summed to obtain a dominance value (Appendix XI-XV) for each species. Species diversity was measured by calculating Simpson's Diversity Index (Appendix I-V).

# III. RESULTS

 **PHYSICAL DATA**

 **SEDIMENT COMPOSITION** - Sand, a hard, high-density sediment, was the predominant sediment at the Arrowhead Lake sample sites in all depth zones (Table 4). Silt, a soft, intermediate-density sediment, was common only at depths greater than 5 feet.

**Table 4. Sediment Composition on Lake Arrowhead, 2000**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sediment Type** | **0-1.5' Depth** | **1.5-5' Depth** | **5-10' Depth** | **10-20’ Depth** | **Percent of all Sample Sites**  |
| Hard | Sand | 69% | 86% | 62% | 45% | 68% |
| **Sediments** | Sand/Gravel | 10% | 3% | 8% | 15% | 9% |
|  | Rock | 17% | 3% | 4% | 1% | 8% |
| **Mixed Sediments** | Sand/Silt | 3% | 3% |  | 15% | 5% |
| **Soft** | Silt/Muck |  | 3% |  |  | 1% |
| **Sediments** | Silt |  |  | 25% | 20% | 20% |

Sand, a hard, high-density sediment, was the predominant sediment at the Sherwood Lake sample sites in all depth zones (Table 5). Silt, a soft, intermediate-density sediment, was common only at depths of 5-10 feet. Mixtures of sand and silt were common at depths greater than 10 feet.

**Table 5. Sediment Composition on Lake Sherwood, 2000**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sediment Type** | **0-1.5' Depth** | **1.5-5' Depth** | **5-10' Depth** | **10-20’ Depth** | **Percent of all Sample Sites**  |
| **Hard** | Sand | 24% | 31% | 50% | 67% | 69% |
| **Sediments** | Sand/Gravel | 9% | 3% |  |  | 3% |
|  | Rock | 18% | 6% | 1% |  | 8% |
| **Mixed Sediments** | Sand/Silt |  | 3% | 14% | 20% | 8% |
| **Soft** | Silt |  |  | 28% | 13% | 10% |
| **Sediments** | Muck |  | 3% | 2% |  | 2% |

Sand, a hard, high-density sediment, was the predominant sediment at the Upper Camelot Lake sample sites in all depth zones (Table 6). Silt, a soft, intermediate-density sediment, was common only at depths greater than 10 feet.

**Table 6. Sediment Composition on Upper Lake Camelot, 2000**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sediment Type** | **0-1.5' Depth** | **1.5-5' Depth** | **5-10' Depth** | **10-20’ Depth** | **Percent of all Sample Sites**  |
| **Hard** | Sand | 83% | 100% | 75% | 67% | 84% |
| **Sediments** | Sand/Gravel | 11% |  |  |  | 3% |
| **Mixed Sediments** | Sand/Silt |  |  | 5% |  | 1% |
| **Soft** | Silt | 6% |  | 10% | 33% | 9% |
| **Sediments** | Silt/Muck |  |  | 5% |  | 1% |
|  | Muck |  |  | 5% |  | 1% |

Sand, a hard, high-density sediment, was the predominant sediment at the Lower Camelot Lake sample sites in all depth zones (Table 7). Silt, a soft, intermediate-density sediment, was common only at depths greater than 10 feet.

**Table 7. Sediment Composition on Lower Lake Camelot, 2000**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sediment Type** | **0-1.5' Depth** | **1.5-5' Depth** | **5-10' Depth** | **10-20’ Depth** | **Percent of all Sample Sites**  |
| **Hard** | Sand | 68% | 90% | 63% | 50% | 69% |
| **Sediments** | Sand/Gravel | 10% |  |  |  | 3% |
|  | Rock | 16% |  |  |  | 4% |
| **Mixed Sediments** | Sand/Silt |  |  | 19% |  | 5% |
| **Soft Sediments** | Silt | 5% | 10% | 16% | 50% | 18% |

Sand, a hard, high-density sediment, was the predominant sediment at the Camelot Lake channel sample sites in all depth zones (Table 8). Silt, a soft, intermediate-density sediment, was common only at depths of 5-10 feet.

**Table 8. Sediment Composition on Lake Camelot Channel, 2000**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sediment Type** | **0-1.5' Depth** | **1.5-5' Depth** | **5-10' Depth** | **10-20’ Depth** | **Percent of all Sample Sites**  |
| **Hard Sediments** | Sand | 90% | 100% | 56% | 100% | 83% |
| **Mixed Sediments** | Sand/Silt | 10% |  |  |  | 3% |
| **Soft Sediments** | Silt |  |  | 44% |  | 13% |

The sediment composition of the Tri-Lakes differed somewhat. Sand was the predominant sediment in all lakes. Upper Camelot Lake had the greatest percentage of sites with sand sediments. Silt sediments were common occurring in only Arrowhead Lake (Table 9).

**Table 9. Sediment Composition by Impoundment**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sediment Type** | **Lake****Arrowhead** | **Lake Sherwood** | **Upper****Camelot** | **Lower****Camelot** | **Camelot****Channel** |
| **Hard** | Sand | 68% | 69% | 84% | 69% | 83% |
| **Sediments** | Sand/Gravel | 9% | 3% | 3% | 3% |  |
|  | Rock | 8% | 8% |  | 4% |  |
| **Mixed Sediments** | Sand/Silt | 5% | 8% | 1% | 5% | 3% |
| **Soft** | Silt | 20% | 10% | 9% | 18% | 13% |
| **Sediments** | Silt/Muck | 1% |  | 1% |  |  |
|  | Muck |  | 2% | 1% |  |  |

 **SHORELINE LAND USE** – Land use practices can strongly impact the aquatic plant community and, therefore, the entire aquatic community. Land use can directly impact the plant community through increased sedimentation from erosion, increased nutrient input from fertilizer run-off and soil erosion and increased toxics from farmland and urban run-off.

Cultivated lawn was the most frequently encountered shoreline cover on the Tri-Lakes, except at Arrowhead Lake (Table 10). On Arrowhead Lake, cultivated lawns were the second most frequently encountered shoreline cover; native herbaceous cover was slightly more frequent. Upper Camelot Lake had the highest frequency of occurrence of cultivated lawn at the study transects in the Tri-Lakes (Table 10).

**Table 10. Frequency of Shoreland Use Categories in the Tri-**

 **Lakes, 2000**

|  |  |
| --- | --- |
| **Cover Type** | **Frequency of Occurrence at Transects** |
| **Lake** **Arrowhead** | **Lake** **Sherwood** | **Upper****Camelot** | **Lower****Camelot** | **Camelot****Channel** |
| Natural Shoreline | Wooded | 43% | 36% | 15% | 15% | 40% |
| Shrub | 20% | 14% | 15% | 15% | 20% |
| Native Herbaceous | 57% | 36% | 30% | 50% | 50% |
| Disturbed  | Cultivated Lawn | 50% | 78% | 85% | 70% | 70% |
| Shoreline | Rip-rap/walls | 30% | 25% | 40% | 40% | 20% |
|  | Sand | 20% | 39% | 35% | 60% | 50% |
|  | Hard Structures | 10% | 39% | 20% | 25% | 60% |
|  | Eroded soil | 23% |  |  |  |  |
|  | Pavement | 10% | 3% |  | 10% |  |
|  | Mulch pile  |  |  | 5% |  |  |

Some type of disturbed shoreline occurred at:

 92% of the sites in Sherwood Lake

 90% of the sites in Upper Camelot Lake

 90% of the sites in Lower Camelot Lake

 90% of the sites on the Camelot Lake Channel

 77% of the sites in Arrowhead Lake

This is only the occurrence of various types of shoreline and does not take into consideration the percentage of area along the shoreline that is covered with each cover type. To get a better understanding of the shoreline impacts the mean coverage of each shoreline type was calculated (Table 11).

Cultivated lawn also had the highest mean coverage at the transect sites on all Tri-Lakes, except Arrowhead (Table 11). Wooded cover was slightly higher on Arrowhead, with lawn having the second highest coverage. Upper Camelot also had the highest mean coverage of lawn.

**Table 11. Mean Coverage of Shoreline Cover Types on the Tri-**

 **Lakes, 2000**

|  |  |
| --- | --- |
| **Cover Type** | **Mean Coverage at Transects** |
| **Lake** **Arrowhead** | **Lake** **Sherwood** | **Upper****Camelot** | **Lower****Camelot** | **Camelot****Channel** |
| Natural Shoreline | Wooded | **30%** | 18% | 13% | 6% | 8% |
| Shrub | 2% | 3% | 2% | 2% | 1% |
| Native Herbaceous | 16% | 8% | 6% | 12% | 30% |
| Disturbed  | Cultivated Lawn | 28% | **49%** | **56%** | **48%** | **49%** |
| Shoreline | Rip-rap/walls | 6% | 5% | 4% | 4% | 2% |
|  | Sand | 9% | 14% | 10% | 26% | 7% |
|  | Hard Structures | 1% | 3% | 3% | 2% | 4% |
|  | Eroded soil | 5% |  |  |  |  |
|  | Pavement | 4% |  |  | 2% |  |
|  | Mulch pile  |  |  | 2% |  |  |

Based on the transect sites, disturbed shoreline covers

53% of the shoreline on Arrowhead Lake

71% of the shoreline on Sherwood Lake

75% of the shoreline on Upper Camelot Lake

82% of the shoreline on Lower Camelot Lake

62% of the shoreline on the Camelot Lake channel.

 **MACROPHYTE DATA**

 **SPECIES PRESENT**

Of the 30 species found in the Tri-Lakes, 10 were emergent species, 2 were free-floating species and 18 were submergent species (Table 12). No threatened or endangered species were found. Two non-native species (*Myriophyllum spicatum, Potamogeton crispus)* were found*.*

# Table 12. Tri-Lakes Aquatic Plant Species

**Scientific Name Common Name I. D. Code**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

## Emergent Species

1) *Carex lacutris* Willd. lake sedge carla

2) *Eleocharis palustris* L. creeping spikerush elepa

3) *Phalaris arundinacea* L. reed canary grass phaar

4) *Polygonum amphibium* L. water smartweed polam

5) *Sagittaria latifolia* Willd. common arrowhead sagla

6) *Salix exigua* Nutt. sandbar willow salex

7) *Scirpus fluviatilis* (Torr.) A. Gray.

 river bulrush scifl

8) *Scirpus validus* Vahl. softstem bulrush sciva

9) *Typha angustifolia* L. narrow-leaf cattail typan

10) *Typha latifolia* L. common cattail typla

## Floating leaf Species

11) *Lemna minor* L. small duckweed lemmi

12) *Spirodela polyrhiza* (L.) Schleiden.

 great duckweed spipo

## Submergent Species

13) *Ceratophyllum demersum* L. coontail cerde

14) *Chara* sp. muskgrass chasp

15) *Eleocharis acicularis* (L.) Roemer & Schultes.

 needle spikerush eleac

16) *Elodea canadensis* Michx. common waterweed eloca

17) *Myriophyllum sibiricum* Komarov.

 common water milfoil myrsi

18) *Myriophyllum spicatum* L. Eurasain water milfoil myrsp

19) *Najas flexilis* (Willd.) Rostkov & Schmidt.

 slender naiad najfl

20) *Nitella* sp. nitella nitsp

21) *Potamogeton amplifolius* Tuckerman.

 large-leaf pondweed potam

22) *Potamogeton crispus* L. curly-leaf pondweed potcr

23) *Potamogeton foliosus* Raf. leafy pondweed potfo

24) *Potamogeton nodosus* Poiret. long-leaf pondweed potno

25) *Potamogeton pectinatus* L. sago pondweed potpe

26) *Potamogeton pusillus* L. small pondweed potpu

27) *Potamogeton zosteriformis* Fern.

 flatstem pondweed potzo

28) *Ranunculus longirostris* Godron.

 white watercrowfoot ranlo

29) *Vallisneria americana* L. water celery valam

30) *Zosterella dubia* (Jacq.) Small

 water stargrass zosdu

None of the individual lakes in the Tri-Lakes contained all of the aquatic plant species.

19 species occurred in Arrowhead Lake

19 species occurred in Sherwood Lake

20 species occurred in Upper Camelot Lake

18 species occurred in Lower Camelot Lake

14 species occurred in the Camelot Channel

 **FREQUENCY OF OCCURRENCE**

*Chara* was the most frequently occurring species in the all of the Tri-Lakes in 2000, (47-75% of sample sites) (Figure 1).

# Figure 1. Frequency of macrophytes in the Tri-Lakes, 2000.

Filamentous algae occurred at

18% of the sample sites in Arrowhead Lake

38% of the sample sites in Sherwood Lake

26% of the sample sites in Upper Camelot Lake

18% of the sample sites in Lower Camelot Lake

32% of the sample sites in the Camelot Lake Channel.

 **DENSITY**

*Chara* sp. was also the species with the highest mean density in all of the Tri-Lakes (1.3-2.4 on a density scale of 1-5) (Figure 2).

**Figure 2. Macrophyte densities in the Tri-Lakes, 2000.**

The mean “density where present” indicates how dense of a growth form a species possesses in the Tri-Lakes. *Chara* had the highest mean “density where present” (2.8-3.4) in all of the Tri-Lakes. These densities indicate that *Chara* possessed a growth form of average-to- slightly above average density in the Tri-Lakes.

Other species that possessed a growth form of slightly above average density in the Tri-Lakes were:

*Potamogeton pusillus, Vallisneria americana, Zosterella dubia* in Sherwood Lake;

*Polygonum aquaticum, Potamogeton nodosus* in Upper Camelot Lake;

*Typha latifolia* in Lower Camelot Lake.

 **DOMINANCE**

Combining relative frequency and relative density into a Dominance Value indicates how dominant a species is within the macrophyte community (Appendix XI-XV). Based on the Dominance

Value, *Chara* sp. was the dominant species in the Tri-Lakes (Figure 3). *Potamogeton pusillus* was sub-dominant species in Arrowhead Lake and Lower Camelot Lake; *Elodea canadensis* was sub-dominant in Sherwood Lake; *Najas flexilis* was sub-dominant in Upper Camelot Lake and the Camelot Lake channel.

**Figure 3. Dominance within the macrophyte community, of the most prevalent macrophytes in the Tri-Lakes, 2000.**

 **DISTRIBUTION**

Within the littoral zone,

80% of the sampling sites were vegetated in Arrowhead Lake

81% of the sampling sites were vegetated in Sherwood Lake

90% of the sampling sites were vegetated in Upper Camelot Lake

86% of the sampling sites were vegetated in Lower Camelot Lake

90% of the sampling sites were vegetated in the Camelot channel.

Rooted aquatic plants occurred throughout the Tri-Lakes, to a maximum depth of:

13 feet in Arrowhead Lake (*Najas flexilis, Potamogeton pusillus);*

12 feet in Sherwood Lake (*Potamogeton pusillus);*

13 feet in Upper Camelot Lake (*Chara* sp.);

13 feet in Lower Camelot Lake (*Myriophyllum spicatum).*

The dominant species, *Chara,* was found throughout all the Tri-Lakes. The subdominant species were also found throughout the lakes, except the subdominant in Sherwood Lake, *Elodea canadensis,* was found predominantly in the south arm in scattered locations along the upstream end.

The 0-1.5 foot depth zone supported the greatest total occurrence and total density of aquatic plants in the Camelot Lake channel (Figure 4, 5). The 1.5-5 foot depth zone supported the greatest total occurrence and total density of aquatic plants in Arrowhead Lake (Figure4, 5). The 5-10 foot zone supported the greatest total occurrence and total density of aquatic plants in Sherwood Lake, upper Camelot Lake and lower Camelot Lake (Figure 4, 5).

**Figure 4. Total occurrence of plants by depth zone.**

**Figure 5. Total density of plants by depth zone.**

The highest percentage of vegetated sites was in the 1.5-10 ft depth zone in Arrowhead Lake, Sherwood Lake and lower Camelot Lake and in the 5-10 foot depth zone in upper Camelot Lake (Figure 6).

Figure 6. Percentage of sites vegetated in Tri-Lakes, by depth.

The 0-1.5 foot depth zone supported the highest mean number of species per site in the Camelot Lake channel (Figure 7). The 1.5-5 foot depth zone supported the highest mean number of species per site in Arrowhead Lake (Figure 7). The 5-10 foot zone supported the highest mean number of species per site in Sherwood Lake, upper Camelot Lake and lower Camelot Lake (Figure 7).

Figure 7. Mean number of species per site in Tri-Lakes, by depth zone.

 **INFLUENCE OF SEDIMENT** - Some plants depend on the sediment in which they are rooted for their nutrients. The richness or sterility and texture of the sediment will determine the type and abundance of macrophyte species that can survive in a location.

The availability of mineral nutrients for growth is highest in sediments of intermediate density, such as silt (Barko and Smart 1986). Silt sediments were not predominant in the Tri-Lakes study sites (9-20%), either alone or mixed with sand or muck (1-8%). Silt sediments supported high percentage of vegetation, 90-100% of the sites at which they occurred, 80-100% in mixture (Table 13).

Sand was the predominant sediment found in Tri-Lakes. Rock and gravel sediments were also common. Sand and rock sediments may be limiting to plant growth due to their high density. In the

Tri-Lakes, however, 83-89% of the sites with sand sediments supported plant growth (Table 13).

**Table 13. Sediment Influence by Impoundment**

 **Percentage of sites vegetated within each sediment type**

 ( ) = Values in ( ) indicate percentage of sites with that sediment type

 in each impoundment.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sediment Type** | **Lake****Arrowhead** | **Lake Sherwood** | **Upper****Camelot** | **Lower****Camelot** | **Camelot****Channel** |
| **Hard** | Sand | 83% (68%) | 86% (69%) | 89% (84%) | 84% (69%) | 88% (83%) |
| **Sediments** | Sand/Rock | 67% (9%) | 75% (3%) | 100% (3%) | 50% (3%) |  |
|  | Rock | 50% (8%) | 11% (8%) |  | 0% (4%) |  |
| **Mixed Sediments** | Sand/Silt | 80% (5%) | 89% (8%) | 100% (1%) | 100% (5%) | 100% (3%) |
| **Soft** | Silt | 90% (20%) | 92% (10%) | 100% (9%) | 100% (18%) | 100% (13%) |
| **Sediments** | Silt/Muck | 100% (1%) |  | 100% (1%) |  |  |
|  | Muck |  | 100% (2%) | 100% (1%) |  |  |

 **THE COMMUNITY**

The Tri-Lakes impoundments were similar in species diversity. Simpson's Diversity Index ranged between 0.88-0.89 in the impoundments themselves and 0.85 in the channel. This indicates good diversity (Table 14). A rating of 1.0 would mean that each plant encountered would be a different species (the most diversity achievable).

**Table 14. Differences in the Macrophyte Communities of the Tri-Lakes impoundments, 2000.**

Other similarities among the four impoundments was the number of plant species found (18-20 in the impoundments and 14 in the channel), the maximum rooting depth of aquatic plants and the absence of floating-leaf species (Table 14).

Differences between the impoundments are seen in the percentage of the littoral zone that is vegetated. The Camelot channel and Upper Camelot Lake supported the highest percentage vegetation (90%) and Arrowhead Lake supported the lowest (80%). Sherwood Lake had the lowest percentage of sites with emergent vegetation (1.7%) and submergent vegetation (80%); Upper Camelot had the highest percent of sites with emergent (5.9%) and the channel had the highest percent with submergent (90%). The channel supported no free-floating species and Lower Camelot Lake supported free-floating species at 13.7% of the sites (Table 14). The floristic Quality is discussed later in this document.

An Aquatic Macrophyte Community Index (AMCI) recently developed for Wisconsin lakes (Weber et. al. 1995) was applied to the Tri-Lakes impoundments. Several parameters that characterize the quality of the aquatic macrophyte community (Table 15) are measured and the data for each is converted to a value 0 - 10 as outlined by Weber et. al. (1995). The maximum AMCI value is 60 and the average AMCI value for Wisconsin lakes is 40. According to the AMCI value, the aquatic communities in the Tri-Lakes impoundments are below average with the highest index in Upper Camelot Lake (37) (Table 15).

Table 15. Aquatic Macrophyte Community Index Values for the Tri-Lakes impoundments, 2000.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Arrow-head | Sher-wood | Upper Camelot | Lower Camelot | Channel |
| Maximum Rooting Depth | 6 | 6 | 6 | 6 | 6 |
| % Littoral Zone Vegetated | 10 | 10 | 10 | 10 | 10 |
| Simpson's Diversity Index | 9 | 9 | 9 | 9 | 9 |
| Relative Frequency of Submersed Species | 4 | 4 | 6 | 4 | 6 |
| Relative Frequency of Sensitive Species | 0 | 0 | 0 | 0 | 0 |
| # of Taxa (reduced by exotic) | 4 | 4 | 6 | 4 | 3 |
| Total | 33 | 33 | 37 | 33 | 34 |

The Coefficients of Community Similarity show that the aquatic plant communities in the Tri-Lakes impoundments are significantly different (Table 16).

 Lakes Arrowhead and Sherwood are only 73-74% similar.

 Lakes Sherwood and Upper Camelot were only 61-63% similar.

 Lakes Sherwood and Lower Camelot were only 70-71% similar.

 The plant community in the Camelot channel was only 61-62% similar to the plant community in Lower Lake Camelot and 73-75% similar to the plant community in Upper Camelot Lake.

 The most dissimilar plant communities were those in Sherwood Lake and the Camelot Lake channel (Table 16).

Table 16. Coefficients of Community Similarity.

 Nichols (1998) recently outlined a method for evaluating the closeness of an aquatic plant community to an undisturbed condition using Coefficients of Conservatism.

 A Coefficient of Conservatism (C) is an assigned value, 0-10, the probability that a species will occur in a relatively undisturbed habitat. The Average Coefficient of Conservatism is the mean of the coefficients of conservatism for all species found in a lake.

Floristic quality (I), calculated from the coefficients of conservatism, is a measure of a plant community’s closeness to an undisturbed condition.

When Nichols applied these metrics to a sample of 554 lakes throughout Wisconsin, the Average Coefficient of Conservatism for all Wisconsin lakes ranged from a low of 2.0 (the most disturbance tolerant) to a high of 9.5 (closest to undisturbed condition). The lowest Floristic Quality was 3.0 (the most disturbance tolerant) to a high of 44.6 (closest to undisturbed condition) (Table 17).

In the North Central Hardwoods Region (NCHR), the region in which the Tri-Lakes impoundments are located, the Average Coefficient of Conservatism lower quartile was 5.2, the mean was 5.6 and the upper quartile was 5.8 (Table 17). The Floristic Quality lower quartile was 17, the mean was 20.9 and the upper quartile was 24.4.

Table 17. Floristic Quality and Coefficient of Conservatism of the Tri-Lake, Compared to Wisconsin Lakes and Northern Central Wisconsin Lakes.

|  |  |
| --- | --- |
|  |  |
|  | **(C)****Average Coefficient of Conservatism** | **(I)****Floristic Quality** |
| Wisconsin Lakes | 5.5, 6.0, 6.9**\*** | 16.9, 22.2, 27.5**\*** |
| NCHR Lakes | 5.2, 5.6, 5.8**\*** | 17, 20.9, 24.4**\*** |
| Tri-Lakes |
| Arrowhead | 4.2 | 17.2 |
| Sherwood | 4.7 | 20.6 |
| Upper Camelot | 4.6 | 19.3 |
| Lower Camelot | 3.9 | 16.2 |
| Camelot Channel | 4.2 | 14.7 |

**\*** upper limit of lower quartile, mean, lower limit of upper quartile.

The Average Coefficient of Conservatism for the Tri-Lakes impoundments aquatic plant species are in the lowest quartile for all Wisconsin lakes and for lakes in the North Central Hardwoods Region (Table 17). This suggests that the plant community in the Tri-Lakes is among the lakes that is most tolerant of disturbance.

The Floristic Quality Indices of the plant communities in the Tri-Lakes is more variable. Arrowhead, Sherwood and Upper Camelot Lakes have a Floristic Quality that is below the mean for lakes in the North Central Hardwoods Region and all Wisconsin Lakes. Lower Camelot Lake and the Camelot channel have a Floristic Quality within the lowest quartile (Table 17). This indicates the plant communities in Arrowhead, Sherwood and Upper Camelot Lakes is more disturbance tolerant than the average lake in the North Central Hardwood Region and Wisconsin; the plant communities in Lower Camelot Lake and the Camelot channel are among the most disturbance tolerant in Wisconsin and the North Central Hardwoods Region.

# V. SENSITIVE AREA DESIGNATION

A sensitive area is an area in a lake that contains aquatic habitat that is especially important to the fish and wildlife resources in that lake.

Areas on the Tri-Lakes that are recommended for designation as Sensitive Areas in the order of importance:

1.) An area on the east end of Upper Camelot Lake (Figure 8) is the only area on Upper Camelot Lake with no disturbance at the shoreline. This area has the highest species diversity on Upper Camelot Lake, is colonized by species that are valuable for habitat (large-leaf pondweed), and is one of few places with emergent plant growth (sedges, bulrush, cattails).

Figure 8. Recommended Sensitive Area on Upper Camelot and Lower Camelot Lakes.

2. Two areas on Sherwood Lake (Figure 9): The first area is in the southeast corner, one of only two areas on Sherwood Lake with no disturbance on the shoreline. The second area in the northeast corner would be a possible sensitive area if the shoreline were kept in a natural state. Both areas are the only sites with emergent plant growth (arrowhead) on Sherwood Lake and both have good species diversity.

Figure 9. Recommended Sensitive Areas on Sherwood Lake.

3.) An area on the east end of Arrowhead Lake (Figure 10) is one of the areas on the lake that has no disturbance on the shoreline, is one of only a couple areas with emergent vegetation (reed-canary grass) and has the highest species diversity in Arrowhead Lake.

Figure 10. Recommended Sensitive Areas on Arrowhead Lake.

4.) An area on the east end of Lower Camelot Lake (Figure 8) is one of only two areas on Lower Camelot Lake with no shoreline disturbance, one of only two areas with emergent plant growth (reed-canary grass, arrowhead, bulrush, and cattails) and one of the areas with the highest species diversity.

**VI. DISCUSSION**

Thirty species of aquatic macrophytes were found in the Tri-Lakes, during the July surveys, each lake having 14-20 different species. Upper Camelot Lake had the greatest number of species and the channel had the least number of species.

*Chara* was the dominant macrophyte species in the Tri-Lakes, occurring throughout all of the impoundments at 47-75% of the sites. *Potamogeton pusillus* was the sub-dominant species in Arrowhead and Lower Camelot Lakes; *Elodea canadensis* was the sub-dominant species in Sherwood Lake; *Najas flexilis* was the sub-dominant species in Upper Camelot Lake and the Camelot Channel.

Aquatic plant growth occurred throughout Tri-Lakes, at 80-90% of the sites, to a maximum depth of 12-13 feet. Arrowhead Lake had the lowest percent of vegetated sites and Upper Camelot Lake had the highest percent of vegetated sites.

Plant growth was more abundant in the 5-10 ft. depth zone in Sherwood Lake, Upper Camelot Lake and Lower Camelot Lake. The highest total occurrence of plants, highest total density of plants, the greatest percentage of vegetated sites and the highest mean number of species per sample site occurred in this depth zone. The depth zone with the most abundant plant growth in Arrowhead Lake was the 1.5-5 ft. depth zone; the most abundant plant growth in the Camelot channel was in the 0-1.5 ft. depth zone.

All Tri-Lakes impoundments had low frequencies of emergent plant growth and no floating-leaf plant growth. Upper Camelot Lake had the highest frequency of emergent plant growth, only 6% of the sample sites. Sherwood Lake had the lowest frequency of emergent plant growth; also the lowest percent of sites with submergent plant growth.

Filamentous algae occurred at 18-38% of the study sites in the Tri-Lakes. The Sherwood Lake impoundment had the highest occurrence of filamentous algae.

The Coefficients of Similarity suggest that the aquatic plant communities in each of the impoundments of the Tri-Lakes are significantly different from each other, except Upper Camelot and the Camelot channel (73-76% similar). The two impoundments that are most similar, although still different, are Arrowhead Lake and Sherwood Lake (74% similar). The most dissimilar impoundments are Sherwood Lake and Upper Camelot Lake (61-63%, 51-53% similar).

Simpson's Diversity Index (0.85-0.89) indicates that the macrophyte community in the Tri-Lakes has average-to-good diversity. The Aquatic Macrophyte Community Index (AMCI) indicates that the macrophyte communities in the Tri-Lakes impoundments are of below average quality for Wisconsin Lakes. Though still below average, Upper Camelot Lake had the highest AMCI quality index of the Tri-Lakes impoundments.

The Coefficients of Conservatism indicate that the aquatic plant communities in the impoundments of the Tri-Lakes are communities that are adapted to disturbance.

The predominance of high-density sand sediments in all of the Tri-Lakes impoundments could limit plant growth. High-density sediments, such as sand and rock, limit plant growth because of the low availability of nutrients. However, 83-89% of the sites with sand sediment in the Tri-Lakes supported vegetation. More favorable silt sediments were more common at depths greater than five feet and were common in Arrowhead Lake. A larger percentage of the sites with silt sediment supported vegetation.

Several methods of managing aquatic plants are currently taking place on the Tri-Lakes: hand-raking by the residents, mechanical harvesting, aquatic herbicides and winter drawdowns.

Aquatic herbicides have been applied every year, except 1998, for the past 31 years to Camelot and Sherwood Lakes. Arrowhead Lake has received chemical treatments for the past 20 years.

1. Large amounts of copper have been applied to the impoundments of the Tri-Lakes. Copper accumulates in the sediment where it can impact at least two important members of the aquatic ecosystem and food web: mollusks (clams and snails) and aquatic insects (Hanson and Stefan 1984) (Naimo 1995).
2. In addition to copper, six other classes of chemicals have been applied to Camelot and Sherwood Lakes and four others have been applied to Arrowhead Lake.
3. One of the chemicals is no longer approved for aquatic applications and another chemical has been implicated in damage to young fish (Armstrong 1974).

Winter drawdowns may be modifying the distribution and composition of the aquatic plant community. The freezing of the sediments would stress plants in the zone exposed during the winter. A few characteristics of the aquatic plant communities in the Tri-Lakes suggest that winter drawdowns may be impacting the community.

1. The most abundant plant growth is found in the 5-10 foot depth zone in Camelot and Sherwood Lakes. This depth zone is deeper than the typical drawdown, beyond the impacts of freezing sediments.
2. Species that are known to decrease with winter drawdown (such as: *Brasenia schreberi*, other lily pad species, *Potamogeton robbinsii*, *Utricularia* spp.) are either, not present in the Tri-Lakes, or present at low frequencies (creeping spike rush, 0-4%) (Nichols and Vennie 1991).
3. Some species that are favored by winter drawdwon are common or dominant in the Tri-Lakes (Nichols and Vennie 1991).
4. *Najas flexilis* is one of the dominant species in the Tri-Lakes a species and known to be favored by winter drawdowns.
5. *Potamogeton nodosus* (16% frequency), *P. zosteriformis* (14% frequency) and *Vallisneria americana* (15% frequency) are common in the Tri-Lakes. These species can be favored by drawdown.

The Tri-Lakes have very little protection from buffers of natural shoreline (wooded, shrub and native herbaceous growth). Cultivated lawn was the most frequently encountered shoreline cover (50-85% of the sites) on all the impoundments except Arrowhead Lake. Cultivated lawn still occurred at 50% of the sites on Arrowhead Lake. Cultivated lawn also had the highest mean coverage of any shoreline cover type on the Tri-Lakes impoundments. Upper Camelot Lake had the highest occurrence and coverage of cultivated lawn at the sample sites. Areas with cultivated lawn could increase run-off of pesticides and nutrients into the lake.

Other unnatural cover types occurred on the shorelines of the Tri-Lakes; rip-rap, retaining walls, hard structures, pavement, mulch piles, eroding soil and bare sand. In all, disturbed shoreline occurred at 77-92% of the sites on the Tri-Lakes and had a mean coverage of 53-82%. This means that about 53-82% of the shoreline on the Tri-Lakes is disturbed.

Restoring a buffer of natural vegetation along the shores will help prevent shoreline erosion and reduce additional nutrient/chemical run-off that can add to algae blooms and sedimentation. Cutting back on mowing near the shoreline would result in better buffers of natural vegetation, less pollution, less fossil fuel burned and less yard work for the residents.

The most important areas for maintaining fish and wildlife habitat in the Tri-Lakes has been recommended for designation as sensitive areas. These areas should be maintained in as natural a state as possible and improved to maintain habitat in the lakes.

**VII. CONCLUSIONS**

# Tri-Lakes Aquatic Plant Community

The aquatic plant communities in the Tri-Lakes are characterized by an average–to-good diversity and below average quality. The plant communities are disturbance tolerant, which indicates that disturbances have determined the composition of the community.

*Chara* sp. is the dominant species in all impoundments of the Tri-Lakes. The communities lack floating-leaf vegetation and adequate amounts of emergent vegetation. Aquatic vegetation is found throughout the littoral zone, up to depths of 12-13 feet.

Filamentous algae is common in all impoundments.

The impoundments had similarities, but each impoundment had its own differences. The Coefficients of Similarity suggest that the plant communities of each impoundment was significantly different from the others, except Upper Camelot Lake and the Camelot channel.

Upper Camelot Lake had the highest quality aquatic plant community, most number of species, the highest frequency of emergents and the greatest percent of vegetated sites.

Lower Camelot Lake had the lowest occurrence of filamentous algae.

Sherwood Lake had the lowest percent of sites with emergent plants and submergent plants and the highest occurrence of filamentous algae.

Arrowhead Lake had the lowest percent of vegetated sites

# Importance of the Aquatic Plant Community

A healthy aquatic plant community plays a vital role within the lake community. This is due to the role plants play in

1) improving water quality 2) providing valuable resources for fish and wildlife 3) resisting invasions of non-native species and 4) checking excessive growth of tolerant species that could crowd out the more sensitive species, reducing diversity.

1. Macrophyte communities improve water quality in many ways:

they trap nutrients, debris, and pollutants entering a

 water body;

they absorb and break down some pollutants;

they reduce erosion by damping wave action and stabilizing

 shorelines and lake bottoms;

they remove nutrients that would otherwise be available for

 algae blooms (Engel 1985).

1. Aquatic plant communities provide important fishery and wildlife resources. Plants (including algae) are the beginning the food chain that supports wildlife and fish. At the same time, they produce oxygen needed by animals. Plants are used as food, cover and nesting/spawning sites by a variety of wildlife and fish (Table 18).

Macrophyte beds of moderate density support adequate numbers of small fish without restricting the movement of predatory fish (Engel 1990). Cover within the littoral zone should be 25-85% to support a healthy fishery. The 26-44% coverage of vegetation within the littoral zone of the Tri-Lakes was low, but adequate.

Compared to non-vegetated lake bottoms, macrophyte beds support larger, more diverse invertebrate populations that in turn will support larger and more diverse fish and wildlife populations (Engel 1985). Additionally, mixed stands of macrophytes support 3-8 times as many invertebrates and fish as monocultural stands (Engel 1990). Diversity in the plant community creates more microhabitats for the preferences of more species.

# Management Recommendations

It is important to take measures to improve and protect water quality and the plant communities that play a key role in protecting water quality:

1. Restore a natural buffer zones of native vegetation along the shore and reduce mowing at shorelines. Large portions of the shoreline on the Tri-Lakes are unnatural and prone to erosion and run-off of nutrients and toxics. Unmowed native vegetation reduces run-off into the lake and filters the run-off that does enter the river.
2. Reduce chemical use for aquatic plant control. Plant control in the Tri-Lakes is currently aimed at native vegetation and unnecessarily adds toxics to the lake. The dying vegetation uses oxygen in the water, adds nutrients to the water as it decays, enriches the sediments at the treatment sites and eliminates habitat from the littoral zone.
3. Continue hand-harvesting the vegetation from around the docks where it is limiting recreation. Investigate the possibility contracting local youth that can be hired by residents to rake vegetation from around docks.
4. Continue machine harvesting in a pattern that will provide edges of vegetation. The “edge-effect” improves the habitat potential of the plant community.
5. Experiment with eliminating winter drawdowns some winters to determine if the diversity and quality of the aquatic plant improves. The risk may be that current winter drawdowns are preventing the Eurasian watermilfoil from dominanting the Tri-Lakes impoundments.

**Table 18. Wildlife Uses of Aquatic Plants in the Tri-Lakes**

| **Aquatic Plants** | **Fish** | **Water****Fowl** | **Shore****Birds** | **Upland****Birds** | **Muskrat** | **Beaver** | **Deer** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Submergent Plants |  |  |  |  |  |  |  |
|  *Ceratophyllum demersum* | F,I\*, C, S | F(Seeds\*), I, C |  |  | F |  |  |
|  *Chara*  sp. | F\*, S | F\*, I\* |  |  |  |  |  |
|  *Eleocharis acicularis* | S | F |  |  | F |  |  |
|  *Elodea canadensis* | C, F, I | F(Foliage) I |  |  |  |  |  |
|  *Myriophyllum sibiricum* | F\*, I\*, S | F(Seeds, Foliage) | F(Seeds) |  | F |  |  |
|  *Myriophyllum spicatum* | F, C |  |  |  |  |  |  |
|  *Najas flexilis* | F, C | F\*(Seeds, Foliage) | F(Seeds) |  |  |  |  |
|  *Nitella* sp. |  | F, I\* |  |  |  |  |  |
|  *Potamogeton amplifolius* | F, I, S\*,C | F\*(Seeds) |  |  | F\* | F | F |
|  *Potamogeton crispus* | F, C, S | F(Seeds, Tubers) |  |  |  |  |  |
|  *Potamogeton foliosus* | F, I, S\*,C | F\*(All) |  |  | F\* | F | F |
|  *Potamogeton nodosus* | F, I, S\*,C | F\*(Seeds) |  |  | F\* | F | F |
|  *Potamogeton pectinatus* | F, I, S\*,C | F\* |  |  | F\* | F | F |
|  *Potamogeton pusillus* | F, I, S\*,C | F\*(All) |  |  | F\* | F | F |
|  *Potamogeton zosteriformis* | F, I, S\*,C | F\*(Seeds) |  |  | F\* | F | F |
|  *Ranunculus longirostris* | F | F(Seeds, Foliage) |  | F |  |  |  |
|  *Vallisneria americana* | F\*, C, I, S | F\*, I | F |  | F |  |  |
|  *Zosterella dubia* | F, C, S | F(Seeds) |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
| Floating-leaf Plants |  |  |  |  |  |  |  |
|  *Lemna minor* | F | F\*, I | F | F | F | F |  |
|  *Spirodela polyrhiza* | F | F |  | F |  |  |  |
|  |  |  |  |  |  |  |  |
| Emergent Plants |  |  |  |  |  |  |  |
|  *Carex lacustris* | S | F(Seeds), C | F(Seeds) | F(Seeds) | F | F | F |
|  *Eleocharis* sp. | F, S, C | F(Tubers, Seeds), C | F(Seeds) | F (Seeds) | F | F | F |
|  *Polygonum amphibium*  | F, C | F\*(Seeds) | F | F | F |  | F |
|  *Sagittaria latifolia* |  | F, C | F(Seeds), C | F | F | F |  |
|  *Scirpus fluviatilis* | F, C, S | F(Seeds) | F | F |  |  |  |
|  *Scirpus validus* | F, C, I | F (Seeds)\*, C | F(Seeds, Tubers), C | F (Seeds) | F | F | F |
|  *Typha angustifolia* | S, C |  |  |  |  | F |  |
|  *Typha latifolia* | I, C, S | F(Entire), C | F(Seeds), C, Nest | Nest | F\* C\*, Lodge | F |  |

**F=Food, I= Shelters Invertbrates, a valuble food source C=Cover, S=Spawning**

**\*=Valuable Resource in this category** \*Current knowledge as to plant use. Other plants may have uses that have not been determined.

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**Appendix XVI. Arrowhead Lake Data 2000**

**Species Found at Transects and Density Ratings**

(Density rating range: 1=sparse; 5=abundant)

| **Transect** | **Species Density Depth: 0-1.5'** | **Species Density Depth: 1.5-5'** | **Species Density Depth: 5-10'** | **Species Dens.** **Depth:10-20'** |
| --- | --- | --- | --- | --- |
| 1 | **1' sand**no vegetation | **2' sand/rock**chasp2 | **5.5' gravel**chasp2 | **11’ gravel**chasp1 |
| 2 | **1' sand**no vegetation (fa) | **2.5' sand**chasp5 potfo2 potpe2 (fa) | **6' sand/gravel**chasp5 | **11' sand/gravel**no vegetation |
| 3 | **0.5' sand**no vegetation | **3' sand**chasp5 potpe1  | **9.5'** potcr2 potpu5 zosdu1 | **11' sand**potpu1 |
| 4 | **1' sand/rock** potpu1 typan2 | **2' sand**chasp4 potpe4 | **8.5' sand**cerde1 chasp2 potpu4 | **12.5' sand**potpu4 |
| 5 | **0.5' rock**no vegetation | **2' sand**chasp2 potpe4 | **9' sand**najfl1 potcr2 potpu4 | **12' sand**cerde1 najfl1 potpu2 |
| 6 | **1' sand**no vegetation | **4.5' sand** eloca1 potcr2 potfo2 potpe1 potpu1 potzo3 zosdu1 | **9.5' sand**potfo1 | **13.5' silt**no vegetation |
| 7 | **1' sand**no vegetation | **4' sand**chasp4 najfl2 potcr2 potpe2 potpu3 | **6.5' sand**chasp2 najfl2 potcr2 potfo2 potzo2 zosdu1 | **11' sand/silt**potfo4 |
| 8 | **0.5' sand**chasp4 potpe1 zosdu1 | **4.5' sand**najfl4 potcr2 potpu1 potzo4 zosdu3 | **7.5' silt**najfl1 potcr2 potpu2 potzo2 zosdu1 | **11.5' silt**cerde1 potpu1 |
| 9 | **1' sand**carla1 chasp2 phaar2 potfo2 potpe1 | chasp2 eloca2 | **8.5' silt**cerde2 eloca2 potcr3 potfo4 potzo1 | **15' sand/silt**no vegetation |
| 10 | **0.5' sand**chasp3 eloca3 lemmi5 spipo4 valam1 wolco4 | **2' sand**cerde2 eloca4 potcr1 potpe2 | **7' sand**chasp3 eloca3 myrsi1 potfo2 | **11' silt**potpu2 |
| 11 | **1' sand**chasp2 potfo1 potpe2 | **3' sand**chasp4 najfl1 potcr2 potpe1 potpu2 | **8'** potpu4 | no depth> 10’ |
| 12 | **0.5' sand**chasp1 eloca1 potpe2 | **3.5' sand**cerde1 chasp3 potcr1 potpe2 potpu2 | **9.5' sand**cerde1 chasp1 potpu4 zosdu1 | no depth> 10’ |
| 13 | **1.5' sand**cerde1 eloca4 lemmi2 myrsi1 myrsp1 najfl1 potpu2 zosdu2 (fa) | **3' sand**cerde4 eloca4 potcr3 potpu2 potzo2 (fa) | No depth > 5’ | no depth> 10’ |
| 14 | Wetland Sedimentation has filled in this area of the lake.  |
| 15 |
| 16 | **1.5' sand/silt**cerde1 chasp3 lemmi1 phaar3 potpe1 potpu3 spipo1 (fa) | **3' silt/muck**cerde4 eloca4 potcr1 potpu2 ranlo1 (fa) | No depth > 5’ | no depth> 10’ |
| 17 | **1' sand**chasp1 eloca4 lemmi4 myrsp1 potpe2  | **4' sand**eloca3 potpe1 potpu2  | **8' silt**eloca4 potfo4 potzo1 | no depth> 10’ |
| 18 | **1.5' sand/rock**chasp2 eloca1 | **3' sand**chasp2 eloca4 najfl2 potfo2 (fa) | No depth > 5’ | no depth> 10’ |
| 19 | **0.5' sand**chasp2 eloca2 najfl1 potfo2 potpe3  | **4' sand** eloca2 potfo4 | **9' sand**cerde1 eloca1 najfl1 potpu2 | no depth> 10’ |
| 20 | **1' rock**potpu1 zosdu1 | **3.5' sand**cerde2 najfl4 potcr3 potfo4 zosdu3  | **9' sand**eloca1 potcr2 potpu4 | **11.5’ sand**no vegetation |
| 21 | **0.5' sand**potfo3 potpe1 potpu2 (fa) | **2.5' sand**chasp1 najfl1 potfo2 potpe2 | **6.5' silt**potfo3 potpu5 | **10.5’ silt**potpu4 |
| 22 | **1' gravel**no vegetation | **2.5' sand**no vegetation | **9' sand**no vegetation | no depth > 10' |
| 23 | **1’ sand**no vegetation (fa) | **3' sand/silt**chasp5 najfl1 zosdu1 | **6’ sand**chasp4 najfl2 potcr3 potpu4 potzo1 | **10.5’ sand/silt**potpu5 |
| 24 | **0.5' sand/rock**no vegetation | **3.5' sand**chasp4 potfo1 potpe3 | **6’ sand**chasp4 najfl2 potfo1 | **11.5’ sand**no vegetation |
| 25 | **1' rock**no vegetation | **2.5' sand**chasp4 eloca1 zosdu1 | **7' sand**chasp2 najfl2 potfo4 (fa) | no depth> 10’ |
| 26 | **1' sand** carla1 potpu1  | **3.5' sand**chasp4 (fa) | **8’ sand**chasp4 najfl1 potpu2 potzo1 | no depth> 10’ |
| 27 | **1’ rock**no vegetation (fa) | **2.5' rock**chasp2 eloca1 najfl2 potcr2 potfo3 potpe1 zosdu1 (fa) | **8’ sand**chasp3 potpu1 | **14.5’ sand**chasp1 |
| 28 | **0.5' sand**no vegetation (fa) | **4' sand**chasp2 (fa) | **9’ sand**chasp1 potcr1 potpu2 potzo1 zosdu1 | **10.5’ sand**potpu1 |
| 29 | **1' sand**najfl2 | **3' sand**chasp2 najfl4 potfo3 potpe1 zosdu1 (fa) | **9’** chasp3 najfl1 potfo1 potpu3 zosdu1 (fa) | **13’ sand**najfl1 potpu2 |
| 30 | No depth < 1.5’ | **3' sand**chasp3 najfl3 potcr1 potpu1 zosdu1 (fa) | **7’ sand/ gravel**chasp2 potcr1 potfo1 potpu3 | **11 sand/gravel**potpu1 |
| 31 | **0.5' sand**no vegetation | **2' sand**chasp3 najfl1 | **6.5' silt**chasp5 | **12’ sand/gravel**no vegetation |
| 32 | **0.5' sand**chasp2 salex2 | **3.5' sand**chasp5 | **9’ silt**chasp5 | **12’ sand**chasp1 |

fa = filamentous algae

**Appendix XVIII. Upper Camelot Lake Data 2000**

**Species Found at Transects and Density Ratings**

(Density rating range: 1=sparse; 5=abundant)

| **Transect** | **Species Density Depth: 0-1.5'** | **Species Density Depth: 1.5-5'** | **Species Density Depth: 5-10'** | **Species Dens.** **Depth:10-20'** |
| --- | --- | --- | --- | --- |
| 1 | **1' sand**no vegetation | **2.5' sand**no vegetation | **7' sand**chasp4 myrsp2 najfl3 potpu1 (fa) | **12’ sand**chasp5 |
| 2 | **1.5' sand/rock**chasp3 najfl2 potpe2 | **3' sand**chasp3 potpe2 | **7' sand**chasp4 | No depth > 10’ |
| 3 | **1.5' sand/rock**chasp3 potfo1 (fa) | **2.5' sand**chasp4 najfl4 potfo1 potpe1 | **6' sand**chasp4 najfl2 potam2 | **10.5' sand**chasp5 |
| 4 | **0.5' sand**no vegetation | **2.5' sand**chasp4 najfl2  | **6' sand**chasp4 myrsp2 najfl2 potam3 potzo1 | **11' sand**chasp1 najfl1 zosdu4 |
| 5 | **1' sand**najfl2 | **4' sand**chasp1 | **6.5' sand**chasp3 potno3 | **11.5' sand**chasp2 myrsp2 potpu3 |
| 6 | **1' sand**chasp3 najfl1 | **4' sand** chasp1 potpe1 | **6' sand**chasp4 myrsp1 potam2 potpu1 | **11' sand**chasp4 myrsp1 potpu4 |
| 7 | No depth < 1.5’ | **3' sand**chasp2 najfl1 potpu1 (fa) | **5.5' sand**chasp4 najfl3 | No depth > 10’ |
| 8 | **1.5' sand**cerde1 eloca1 myrsp3 najfl4 potzo1 (fa) | **3' sand**chasp2 myrsp2 najfl2 (fa) | **8' muck**chasp3 myrsp2 najfl1 potam1 potpu1 potzo1 (fa) | No depth > 10’ |
| 9 | **1' sand**carla2 cerde2 eleac1 eloca1 myrsp4 potno3 sciva1 typan4 (fa) | **3.5' sand**cerde3 eloca3 myrsp5 potam1 potzo1 | **5.5' sand**cerde3 eloca3 myrsp4 potam1 zosdu1 (fa) | No depth > 10’ |
| 10 | **1' sand**carla2 cerde2 eloca3 myrsp4 najfl3 potno3 typan2 (fa) | **4' sand**cerde3 eloca2 myrsp4 potno1 potpu1 potzo1 | **7' silt/muck**cerde4 chasp1 eloca3 myrsp4 potam1 zosdu2 (fa) | No depth > 10’ |
| 11 | **0.5' silt**carla2 eloca3 lemmi2 myrsp3 najfl2 sciva3 typan1 (fa) | **3' sand**najfl2 potzo1 | **5.5' sand**cerde2 chasp4 myrsp3 zosdu1 | No depth > 10’ |
| 12 | **0.5' silt**myrsp2 najfl2 polam3 potpu1 sciva4 typan4 (fa) | **3' sand**chasp3 eloca1 najfl3 (fa) | **6' sand**chasp4 cerde1 myrsp1 potam2 potpu1 zosdu1 | No depth > 10’ |
| 13 | **0.5' sand**no vegetation | **2' sand**chasp4 najfl1 valam1 | **5.5' sand**chasp2 myrsp1 potpu2 potzo3 (fa) | No depth > 10’ |
| 14 | **0.5' sand**no vegetation | **2.5' sand**chasp2 najfl1 zosdu1 (fa) | **9' sand**chasp1 myrsp1 potcr1 potfo2 zosdu3 (fa) | **12' sand**chasp1 potfo5 zosdu3 |
| 15 | **1' sand**myrsp1 najfl1 | **3' sand**chasp3 potpu1  | **7.5' silt**chasp4 potpu2 | No depth > 10’ |
| 16 | **0.5' sand**chasp3 najfl3 potpe2 (fa) | **2' sand**chasp4 najfl3 potfo1 | **9' sand**chasp5 myrsp1 potam1 potfo3 potzo1 zosdu1  | No depth > 10’ |
| 17 | **1' sand**chasp1 najfl1 potpe3  | **3.5' sand**chasp4 najfl2 potpe3 | **8.5' sand/silt**chasp5 potzo1 | **11' silt**chasp1 potcr1 potfo1 zosdu1 |
| 18 | **0.5' sand**chasp2 najfl3 | **2.5' sand**chasp4 najfl3 potpe2 (fa) | **7' silt**chasp5 potcr1 potfo2 potzo1 | No depth > 10’ |
| 19 | **1' sand**chasp2 | **3' sand** chasp4 najfl1 potpe3 | **8' sand**chasp3 najfl1 potpe2 | **13' silt**chasp3 |
| 20 | **1' sand**no vegetation | **2' sand**no vegetation | **6’ sand** chasp5 | **10.5’ silt**chasp5 |

fa = filamentous algae

**Appendix XVII. Sherwood Lake Data 2000**

**Species Found at Transects and Density Ratings**

(Density rating range: 1=sparse; 5=abundant)

| **Transect** | **Species Density Depth: 0-1.5'** | **Species Density Depth: 1.5-5'** | **Species Density Depth: 5-10'** | **Species Dens.** **Depth:10-20'** |
| --- | --- | --- | --- | --- |
| 1 | **1' rock**no vegetation | **2.5' rock**no vegetation | **7.5' rock**no vegetation | **11’ sand**no vegetation |
| 2 | No depth < 1.5ft | **2' sand**chasp1 potpe1  | **8' sand**potfo3 zosdu5 | **11.5' sand**potfo1 |
| 3 | **1' sand**no vegetation (fa) | **2.5' sand**chasp5 potpe2 (fa) | **8.5' sand**chasp2 najfl1 potpu5 | **11' sand/silt**potpu4 |
| 4 | No depth < 1.5’ | **2.5' sand**chasp5 (fa) | **8.5' sand**chasp1 myrsp3 potpu5 | no depth > 10’ |
| 5 | **1' sand**chasp1 eleac1 | **3' sand**chasp5 najfl1 (fa) | **7.5' silt**cerde1 chasp3 eloca2 myrsi1 nitsp3 (fa) | no depth > 10’ |
| 6 | **1' sand**chasp1 eloca2 potpe2 (fa) | **3' sand** chasp5 najfl3 (fa) | **8' muck**cerde1 eleac1 eloca1 potpu5 (fa) | no depth > 10’ |
| 7 | **1' rock**no vegetation | **2' sand**chasp5 eloca4 najfl2 | **7' silt**chasp3 eloca4 potcr2 potpu4 | **11' sand/silt**eloca1 potpu2 |
| 8 | **1' sand**eleac1 eloca2 nitsp1 | **2' sand**no vegetation | **7' silt**eloca5 potfo5 | no depth > 10’ |
| 9 | **0.5' sand**eloca2 (fa) | **2' sand**eleac2 eloca1 (fa) | **7' silt**no vegetation | no depth > 10’ |
| 10 | **0.5' sand**no vegetation | **3' sand**chasp3 eloca3 najfl3 potpu1 | **8' sand**cerde1 eloca4 myrsp1 potcr1 potfo4 | no depth > 10’ |
| 11 | **0.5' sand**no vegetation | **3' sand**eloca1 myrsp2 | **7' silt**cerde3 eloca5 myrsp1 | no depth > 10’ |
| 12 | **1' sand**chasp2 eloca1 | **4' sand**chasp4 eloca2 najfl1 (fa) | **8' sand/silt**cerde2 eloca5 nitsp2 | no depth > 10’ |
| 13 | **1' sand**eloca3 najfl2 (fa) | **3' sand**eloca4 myrsp1 najfl3 nitsp1 (fa) | **6' sand/silt**cerde2 eloca5 nitsp4 (fa) | no depth > 10’ |
| 14 | **1.5' sand/silt**cerde3 eloca2 lemmi1 sagla1 (fa) | **2' muck**cerde1 potpe2 (fa) | **6' muck**cerde2 eloca5 potcr1 potpe1 (fa) | no depth > 10’ |
| 15 | **1.5' sand/gravel**chasp1 eloca3 najfl3 potpe1 | **2.5' sand**cerde1 chasp4 eloca5 (fa) | **7.5' silt**cerde4 eloca5  | no depth > 10’ |
| 16 | **0.5' rock**no vegetation | **4' rock**chasp1 eloca2 | **6' sand/silt**cerde2 eloca4 nitsp1 | no depth > 10’ |
| 17 | **1' sand**no vegetation | **3' sand/silt**cerde1 chasp5 eloca5 (fa) | **7' sand/silt**cedre4 eloca5 potzo1 zosdu1 | **10' silt**cerde1 eloca4 potfo2 potpu2 |
| 18 | **1.5' sand**chasp3 potpe2 | **2' sand**chasp5 eloca2 najfl1 potpe2 | **8.5' sand**cerde1 eloca4 myrsi1 potcr3 potfo4  | **11' silt**cerde1 eloca1 myrsi1 nitsp3 |
| 19 | **1' sand**cerde1 najfl2 (fa) | **2.5' sand** eleac1 eloca5 najfl3 (fa) | **9' silt**cerde5 eloca3 myrsi3 potpu5 | no depth > 10’ |
| 20 | **0.5' sand**eloca1 (fa) | **2' sand**chasp5 eloca2 najfl2  | **8.5' sand**cerde1 chasp1 najfl1 potfo3 valam2 | no depth > 10’ |
| 21 | **0.5' sand**chasp5 eloca1 potfo1 potpe1 (fa)  | **2.5' sand**chasp4 eloca1 (fa) | **8' sand/silt**eloca3 potcr1 potfo5 (fa) | **11’ sand** chasp1 eloca1 myrsp1 potpu4 |
| 22 | **0.5' sand/gravel**no vegetation | **3' sand**chasp5 najfl2 potpe1 potpu1 | **5.5' sand**chasp5 najfl2 | **12’ sand/silt**no vegetation |
| 23 | No depth < 1.5’ | **2' sand/gravel**chasp4 potpe1 | **8’ sand**chasp4 potpu4 potzo1  | **12’ sand**potpu2 |
| 24 | **1' rock**no vegetation | **2' sand**chasp5 potpe1  | **6.5’ sand**chasp5 najfl1 potpe1 potpu2 | **10’ sand**myrsi2 potpu5 |
| 25 | **1.5' sand**chasp4 eloca1 potpe4 (fa) | **2.5' sand**chasp5 najfl2 potpe1 | **7' sand**chasp2 potpu5 | **12’ sand**potpu2 |
| 26 | **0.5' rock**no vegetation (fa) | **2' sand**chasp2 (fa) | **9’ sand**myrsi1 potpu5 | **11’ sand**potpu3 |
| 27 | **1’ sand**chasp2 potfo1 potpu1 (fa) | **3' sand**chasp3 myrsp1 spipo1 (fa) | **7’ sand**chasp3 myrsi1 potcr1 potpu1 | no depth > 10' |
| 28 | **0.5' sand**no vegetation | **2.5' sand**cerde1 chasp2 eloca1 najfl5 (fa) | **6 sand**chasp2 potcr1 potfo1 potpe1 | no depth > 10' |
| 29 | **0.5' sand**no vegetation (fa) | **2.5' sand**chasp2 najfl1 (fa) | **7.5’ silt**chasp5 nitsp1 potcr1 potfo2 | no depth > 10' |
| 30 | **1’ sand**scifl2 | **2.5’ sand**chasp5 najfl2 potpe1 (fa) | **8’ sand/silt**cerde5 chasp2 eloca2 myrsi1 nitsp3 potzo1 | no depth > 10' |
| 31 | **1.5’ sand**chasp4 (fa) | **2.5’ sand**chasp5 najfl3 (fa) | **8.5’ sand**cerde2 myrsi1 potcr1 potpe2 | no depth > 10' |
| 32 | **1’ sand**chasp1 (fa) | **2’ sand**chasp4 myrsp1 najfl1 (fa) | **6’ sand**cerde1 chasp5 myrsi3 potcr1 potfo1 (fa) | no depth > 10' |
| 33 | **1' sand**no vegetation | **3' sand**chasp4 najfl2 potzo1 | **7.5’ silt**chasp4 myrsi3 potcr1 potpu4 (fa) | no depth > 10' |
| 34 | **0.5' rock**no vegetation (fa) | **3' sand**chasp4 najfl1 potfo1 potpe1 (fa) | **5.5' sand**chasp4 najfl2 potpu1 valam4 | **10.5’ sand**potpu5 |
| 35 | **1.5’ sand**no vegetation | **3.5' sand**chasp4 najfl2 potpe2  | **6 sand**chasp3 najfl2 potfo2 | **11.5’ sand**potfo5 |
| 36 | **1' sand**no vegetation (fa) | **3.5' sand**chasp4 najfl2 potpe3 (fa) | **6’ sand** chasp4 najfl2 potpe1 (fa) | **12’ sand**no vegetation |

fa = filamentous algae

**Appendix XIX. Lower Camelot Lake Data 2000**

**Species Found at Transects and Density Ratings**

(Density rating range: 1=sparse; 5=abundant)

| **Transect** | **Species Density Depth: 0-1.5'** | **Species Density Depth: 1.5-5'** | **Species Density Depth: 5-10'** | **Species Dens.** **Depth:10-20'** |
| --- | --- | --- | --- | --- |
| 1 | **1' sand**chasp4 | **2' sand**chasp4 | **9.5' silt**chasp4 potpu1 | No depth > 10’ |
| 2 | **0.5' rock**no vegetation (fa) | **2' sand**chasp3 najfl4 potpe3 (fa) | **6' sand/silt**chasp3 najfl2 potpe1 | **11' silt**chasp2 potpu1 |
| 3 | **0.5' sand**no vegetation | **2' sand**chasp5 najfl4 | **7' sand**chasp4 myrsp1 potpu4 zosdu1 | **11' silt**potpu4 zosdu1 |
| 4 | **0.5' sand**no vegetation | **2.5' sand**chasp2  | **5.5' sand**chasp4 eloca1 najfl1potcr1 potpu4 valam1 | **12' sand**potpu3 |
| 5 | **0.5' sand/rock**no vegetation (fa) | **3.5' sand**chasp5 potpe4 | **5' sand**chasp4 najfl2 potpe2 zosdu1 | **11.5' sand**chasp1 eloca1 myrsp1 potpu4 |
| 6 | **0.5' sand**potpe2 | **2.5' sand** chasp3 najfl1 potpe1 | **7.5' sand/silt**chasp4 myrsp1 pofo1 valam2 | **12.5' sand**no vegetation |
| 7 | **0.5' sand**chasp1 potpe2 | **3.5' sand**chasp5 eloca1 potpe1 potpu1 (fa) | **8' sand**eloca2 potpu3 valam4 | **11' silt**eloca1 myrsp2 potpu4 |
| 8 | **0.5' sand**no vegetation | **3' sand**chasp4 eloca1 myrsp2 najfl3 valam1 | **8' sand**cerde1 eloca2 myrsp3 nitsp1 potpu3 | **11' silt**cerde1 myrsp2 potpu3 |
| 9 | **0.5' silt**cerde1 eloca4 myrsp2 phaar2 sagla1 sciva1 | **3' silt**cerde1 eloca4 myrsp3 | **6' silt**cerde1 eloca4 myrsp2 potpu2 valam3 zosdu1 | No depth > 10’ |
| 10 | **1.5'**eloca1 sagla1 sciva2 typla4 (fa) | **2' silt**cerde2 eloca3myrsp1 | No depth > 5’ |  |
| 11 | **1' sand/rock**chasp1 | **3' sand**chasp5 eloca3  | **7.5' sand/silt**myrsp3 potpu1 valam2 | No depth > 10’ |
| 12 | **0.5' sand**cerde1 myrsp1 (fa) | **3' sand**potfo1 potpe1 valam1 moss3 (fa) | **7.5' sand**cerde2 chasp2 eloca1 myrsp3 potpu2 valam2 zosdu2 moss3 | **12' silt**myrsp1 moss2 |
| 13 | **0.5' sand**chasp2 najfl1 | **3' sand**chasp4 najfl2 | **7' sand**chasp2 valam1 | **10.5' sand**eloca1 myrsp2 potpu2 |
| 14 | **1' sand**no vegetation | **2.5' sand**chasp3 najfl2 | **6.5' sand**chasp5 potpu3 | **13' silt**myrsp2 |
| 15 | **1' sand**chasp3 potfo1 potpe3 (fa) | **4' sand**chasp2 najfl3 valam1 (fa) | **9' sand/silt**potfo2 valam4 | **11' sand** myrsp1 potpu2 |
| 16 | **0.5' rock**no vegetation (fa) | **2' sand**chasp4 potpe1 | **7' sand**chasp4 najfl1 | **13' silt**myrsp1 |
| 17 | **1' sand**chasp2 eleac2 najfl4  | **3.5' sand**chasp4 myrsp1 potfo1 zosdu1 | **8' sand/silt**cerde1 chasp3 eloca2 potpu1 | No depth > 10’ |
| 18 | **0.5' sand**chasp4 najfl4 | **4' sand**chasp5 myrsp1 najfl2 | **7' silt**chasp4 eloca4 potcr2 potpu2  | No depth > 10’ |
| 19 | **1.5' sand**chasp4 phaar1 (fa) | **3.5' sand** chasp4 najfl4 | **6' sand**chasp5 | **14' sand**no vegetation |
| 20 | **0.5' rock**no vegetation (fa) | **4.5' sand**chasp4 (fa) | **8.5' sand**chasp3  | **11' sand**chasp3 |

fa = filamentous algae

**Appendix XX. Camelot Lake Channel 2000**

**Species Found at Transects and Density Ratings**

(Density rating range: 1=sparse; 5=abundant)

| **Transect** | **Species Density Depth: 0-1.5'** | **Species Density Depth: 1.5-5'** | **Species Density Depth: 5-10'** | **Species Dens.** **Depth:10-20'** |
| --- | --- | --- | --- | --- |
| 1 | **0.5' sand**myrsp1 najfl2 potpe1 (fa) | **4.5' sand**chasp2 najfl2 potpe1 zosdu1 | **8.5' silt**eloca1 myrsp1 potcr1 potpu5 zosdu1 | No depth > 10’ |
| 2 | **1' sand**eleac1 phaar1 potno2 (fa) | **3.5' sand**chasp3 najfl2 (fa) | **6' silt**chasp1 myrsp1 najfl2 potpe1 potpu1 zosdu1 (fa) | No depth > 10’ |
| 3 | **0.5' sand**chasp2 najfl2 potno1 potpu1 (fa) | **3.5' sand**chasp2 najfl4 potpu1 | **8' sand**no vegetation | No depth > 10’ |
| 4 | **0.5' sand**chasp2 najfl4 potno3, potzo1 | **3' sand**chasp4 najfl3 potno3 | **7.5' sand**eleac1 eloca1 potpu2 zosdu2(fa) | No depth > 10’ |
| 5 | **0.5' sand**carsp1 chasp4 eleac2 najfl2 phaar1 potno2 typan1 | **3' sand**chasp3 najfl1 | **6.5' silt**chasp3 zosdu3 | No depth > 10’ |
| 6 | **0.5' sand/silt**carsp2 chasp3 eleac1 phaar2 typan2 (fa) | **3' sand** chasp5 najfl1 | **5.5' sand**chasp5 (fa) | No depth > 10’ |
| 7 | **0.5' sand**chasp4 najfl1 | **2.5' sand**chasp4 najfl3 | **8' silt**chasp5 (fa) | No depth > 10’ |
| 8 | **1' sand**chasp1 (fa) | **4.5' sand**chasp3 najfl2 | **9' sand**chasp2 myrsp1 potpu3 zosdu2 | No depth > 10’ |
| 9 | **0.5' sand**no vegetation | **3' sand**chasp2 najfl2 | **5.5' rock**chasp4 myrsp1 | **13' sand**myrsp1 |
| 10 | **0.5' sand**no vegetation | **3 sand**chasp3 | **6' sand**chasp4 myrsp1 | No depth > 10’ |

fa = filamentous algae