ECOLOGICAL STUDY

HIDDEN LAKE, 2006

HADDAM, CT

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For
HIDDEN LAKE ASSOCIATION, HADDAM, CT

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INTRODUCTION

The first ecological survey of Hidden Lake was undertaken during the 1995 growing season (Baillie, 1995). The study described characteristics of the lake and provided baseline limnological and biological data. It encompassed a discussion of lake and watershed dimensions, a five month survey of physical and chemical conditions in the lake, and a listing of the phytoplankton and aquatic plants present during that summer. The study concluded that the lake is a shallow mesotrophic system (moderately enriched) with an extensive plant community. Lake and watershed management methods were discussed.

Recently, members of the Hidden Lake Association became concerned about the growth of plants and algae. A follow-up study was carried out in June, July and August, 2006. This report compares current phytoplankton and plant distributions, water chemistry and trophic status with data for the same three months in 1995.

METHODS

Sampling was carried out on June 12, July 14 and August 10, 2006. One station in the deepest area of the lake was sampled (Figure 1). The depth of the water was measured with a plumb line, and G.P.S. coordinates were recorded on each sampling occasion. Water temperature, dissolved oxygen and conductivity measurements were made at half meter intervals (1.6 ft) from surface to bottom using Y.S.I. meters and submersible probes. Water clarity was measured by lowering a standard size white disk (Secchi disk) into the water and recording the depth at which it disappeared from view. A surface sample was collected at a depth of about 0.3 m (1 ft). Alkalinity and pH determinations were made in the laboratory the same day (Hach alkalinity test kit and Hach One pH meter). The nitrogen series (nitrate-N, nitrite-N, ammonia-N, total organic nitrogen) and total phosphorus were analyzed using standard methods. Phytoplankton preserved in Lugol's solution were identified to genus and counted under the microscope at 100X magnification. Phytoplankton biomass was quantified

Figure 1
HIDDEN LAKE
HADDAM, CT

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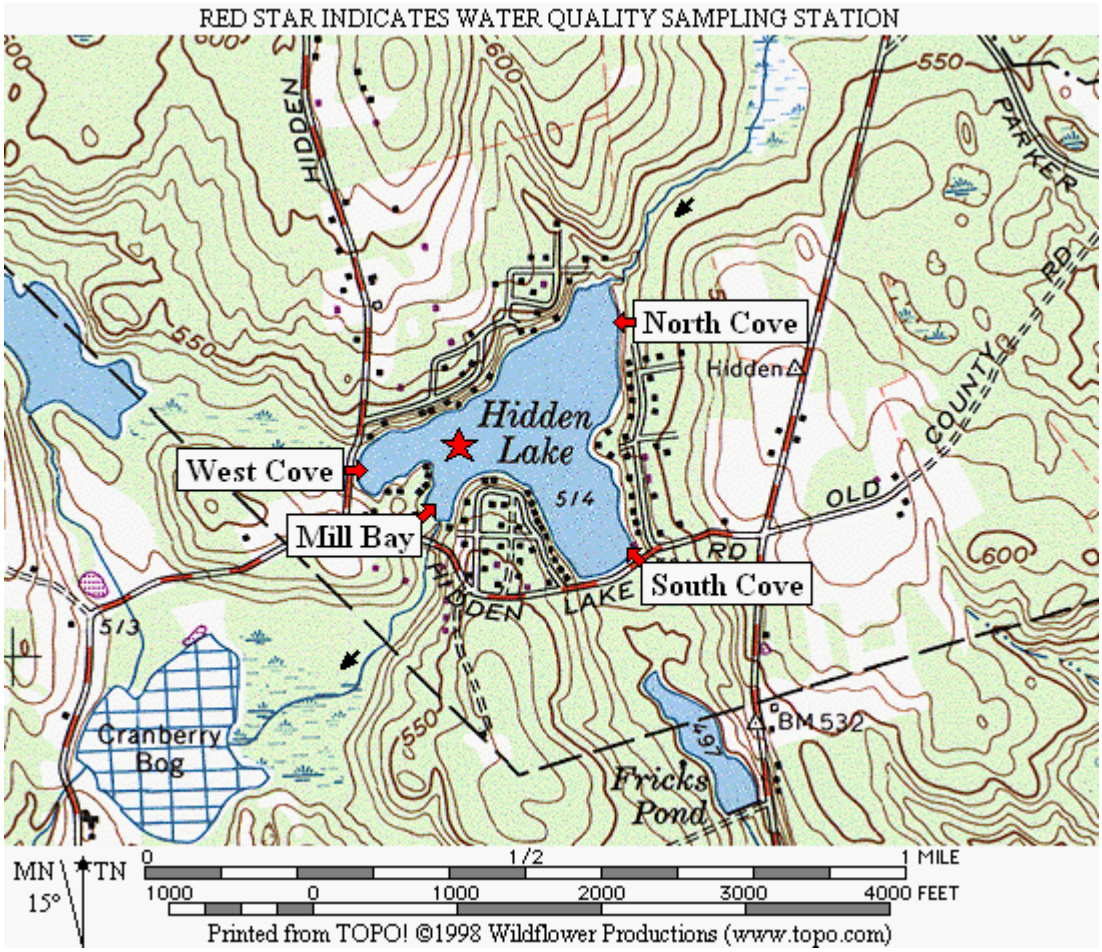
From



U.S.G.S. Topographical Map, Haddam Quadrangle

as the concentration of chlorophyll a using a Turner fluorometer and buffered acetone extractions. Zooplankton were collected using a 80 μm mesh net towed horizontally for several minutes. The animals were stained and preserved in a rose bengal/alcohol solution, and counted at 40 X magnification. Aquatic plants were observed and identified in the field using an Aquascope II bottom viewer. Laboratory analyses of nutrients were carried out by Connecticut Testing Laboratories, Meriden, CT. All other analyses were done by Marine and Freshwater Research Service. Data from the 1995 study is shown in Appendix A. Descriptions of the variables included in both studies were given in the 1995 report and will not be repeated here. A Glossary of ecological terms is provided at the end of this report.

WATER QUALITY

Temperature and Dissolved Oxygen

Water temperature throughout the lake was quite uniform during both studies. A difference of 2.3 ^{o}C was seen in June of 2006 between surface and bottom, but the difference was usually 1 ^{o}C or less, indicating that this shallow system is well mixed (Table 1).

Oxygen profiles indicated that the lake was very well oxygenated during the summer of 1995 and in June, 2006. Moderate to low concentrations occurred in July and August of this year due a prolonged period of hot weather and reduced flow. Levels were also low near the sediments where oxygen is naturally depleted by the decomposition of organic material. The Connecticut State Standard for dissolved oxygen is 5 mg/l (CTDEP, 2002). Many fish and other pond organisms cannot survive at lower concentrations. The lack of oxygen during hot weather in summer, or under the ice in winter, is the most common cause of fish kills. However, oxygen levels throughout most of the water column exceeded this standard both years, indicating that this lake provides good habitat for fish and other animals.

HIDDEN LAKE **Table 1**
Haddam, CT **PHYSICAL CHEMICAL CHARACTERISTICS**

June 12, 2006
Weather: Full sun, cloudless, light breeze Depth: 2.24 m
Water: Surface clear, slightly rippled Time: 0940
Secchi: 1.32 m GPS: N 41 25,236 W 072 34,271

Depth meters	Temp. oC	D.O. mg/l	Conduct. umhos/cm	pH	Alkal. mg/l	NO3-N mg/l	NO2-N mg/l	NH4 mg/l	TON mg/l	TN mg/l	T.P. mg/l	Chloro.a ug/l	Phaeo.a ug/l
Surface	18.3	9.2	49	6.37	15	BDL	0.005	0.015	0.112	0.132	0.010	5.501	1.590
0.5	17.9	8.9	49										
1.0	17.0	8.7	46										
1.5	16.8	8.7	45										
2.0	16.0	7.1	47										
2.5	16.0	3.1	52										
Bottom	16.0	0.8	56										

July 14, 2006
Weather: Cloudless, calm, hot and dry Depth: 1.95 m
Water: Clear, dark brown Time: 0920
Secchi: 1.39 m GPS: N 41 24,224 W 072 34,279

Depth meters	Temp. oC	D.O. mg/l	Conduct. umhos/cm	pH	Alkal. mg/l	NO3-N mg/l	NO2-N mg/l	NH4 mg/l	TON mg/l	TN mg/l	T.P. mg/l	Chloro.a ug/l	Phaeo.a ug/l
Surface	25.0	6.3	61	6.46	20	0.100	0.005	0.020	0.579	0.704	0.020	5.453	2.796
0.5	25.0	5.8	62										
1.0	24.6	5.3	64										
1.5	24.5	3.4	65										
Bottom	23.9	0.8	68										

August 10, 2006
Weather: Full sun, cloudless, light breeze Depth: 2.14 m
Water: Clear, dark color Time: 0930
Secchi: 1.71 m GPS: N 41 24,239 W 072 34,285

Depth meters	Temp. oC	D.O. mg/l	Conduct. umhos/cm	pH	Alkal. mg/l	NO3-N mg/l	NO2-N mg/l	NH4 mg/l	TON mg/l	TN mg/l	T.P. mg/l	Chloro.a ug/l	Phaeo.a ug/l
Surface	26.9	6.1	71	6.66	20	0.010	0.014	0.056	0.637	0.717	0.010	5.612	6.720
0.5	26.9	6.1	70										
1.0	26.4	6.0	70										
1.5	26.2	5.9	70										
2.0	26.0	4.4	71										
Bottom	26.0	3.6	71										

ABBREVIATIONS:

oC = Degrees Celsius
mg/l = Milligrams/liter
ug/l = Micrograms/liter
umhos/cm = Micromhos/centimeter
Temp. = Temperature
D.O. = Dissolved Oxygen
Conduct. = Conductivity
Akal. = Alkalinity
Chloro. = Chlorophyll a
Phaeo. = Phaeopigment a
NO3-N = Nitrate Nitrogen
NO2-N = Nitrite Nitrogen
NH4-N = Ammonia Nitrogen
T.O.N. = Total Organic Nitrogen
T.N. = Total Nitrogen
T.P. = Total Phosphorus

Alkalinity, pH and Conductivity

Alkalinity, measured as the concentration of calcium carbonate ($CaCO_3$), is related to water hardness. Alkalinity levels were very similar in both studies, ranging from 15 mg/l to 20 mg/l $CaCO_3$. Readings of pH ranged from 6.93 to 7.20 in 1995, and from 6.37 to 6.66 in 2006. These alkalinity and pH values are within the range expected for a soft water lake located east of the Connecticut River (Canavan and Siver, 1995).

In 1995, conductivity ranged between 63 μmhos/cm and 75 μmhos/cm. Levels were slightly lower in 2006, falling between 49 μmhos/cm and 71 μmhos/cm. Under low oxygen conditions, nutrients and other ions are released from the sediments. A modest increase in conductivity near the bottom during both studies may have been caused by this process.

Nutrients

Total nitrogen in the lake consists of four different forms (nitrate, nitrite, ammonia, and total organic nitrogen), collectively known as the nitrogen series. Nitrate (NO_3), is the form most readily used by plants and algae, and only nitrate was measured in 1995. The 2006 study included all four constituents. Nitrate was undetectable in 1995 and very low in 2006 due to rapid uptake by abundant aquatic plants during the growing season. Although aquatic plants obtain phosphorus from the sediments through their roots, they absorb much of their nitrate from the surrounding water. In 2006, Nitrite (NO_2), ammonia (NH_4) and total organic nitrogen (TON) concentrations were low to moderate. Total nitrogen (the sum of the four components) ranged from an acceptable level of 0.132 mg/l in June to a rather high concentration of 0.717 mg/l in August.

Total phosphorus is the most important nutrient limiting algal growth in many aquatic systems. In the lake, total phosphorus ranged from undetectable in August 1995 to 0.020 mg/l in 2006. As will be discussed below, Hidden Lake has benefited from these consistently low phosphorus concentrations.

Humic Substances and Dystrophic Features

A distinctive characteristic of this lake is the clear darkly stained water. The dark coloration was noted during all field trips in 1995 and 2006. The color is caused by humic organic material derived from the microbial breakdown of plants. The accumulation of humic substances in lakes is linked to the scarcity of calcium which blocks normal bacterial action (Cole, 1979). Where calcium is not available to the bacteria, organic matter does not decay rapidly and is not recycled in the usual fashion. Alkalinity readings indicated that calcium levels were quite low in Hidden Lake. This chemical property would account for the brown hue of the water.

The dark color has a number of important ecological consequences (Wetzel, 2001). The presence of humic substances may increase the natural acidity, and thus reduce pH. In Hidden Lake, pH was low to moderate. Light penetration may be reduced. Transparency was less than expected given the apparent clarity of the water. Also, the light spectrum may be altered, lowering rates of photosynthesis and reducing algal populations. As discussed below, phytoplankton numbers and biomass were generally low. Humic acids can also sequester phosphorus, causing it to precipitate to the bottom and limiting its availability to plants and algae. Phosphorus levels in the lake were low to undetectable. The term dystrophic describes lakes with high humic content, and applies to Hidden Lake. This condition is somewhat unusual in Connecticut, but does not signify any degradation of water quality.

TROPHIC STATUS

A full discussion of trophic status (level of enrichment) is given in the 1995 report. One of the goals of the 2006 study was to reexamine the trophic status of the lake based on the standard criteria of chlorophyll a, total nitrogen and total phosphorus. One of the criteria usually used, Secchi readings of water clarity, was not appropriate since the secchi disk was frequently visible to the bottom, and an accurate reading could not be made. Trophic limits

for the three remaining criteria are shown in Table 2 (Canavan and Siver, 1995; CTDEP, 2002). The data indicate that the lake is mesotrophic and that the trophic status has not changed over the 11 years intervening between the two studies. Apparently, the condition of the lake has remained stable over this period.

Table 2

TROPHIC LIMITS

Status	**Total Phos.** (mg/L)	**Total Nitrogen** (mg/L)	**Chlorophyll a** (ug/L)
Oligotrophic	<0.010	<0.200	<2
Early Mesotr.	0.010 - 0.015	0.200 - 0.300	2 - 5
Mesotrophic	0.015 - 0.025	0.300 - 0.500	5 - 10
Late Mesotr.	0.025 - 0.030	0.500 - 0.600	10 - 15
Eutrophic	>0.030	>0.600	>15

HIDDEN LAKE AVERAGE DATA FOR JUNE, JULY AND AUGUST

Year	**Total Phosphorus** (mg/L)	**Total Nitrogen** (mg/L)	**Chlorophyll a** (ug/L)	**Trophic Status**
1995	0.013	Not Done	7.373	**Mesotrophic**
2006	0.013	0.518	5.522	**Mesotrophic**

Limited water quality data were developed by the Connecticut Agricultural Experiment Station (CAES) during their invasive plant survey of the lake in 2005 (Appendix B). Although their study found slightly higher conductivity, together with lower alkalinity and pH, the data generally corroborated the findings of the 1995 and 2006 reports, indicating that the lake is a well oxygenated mesotrophic soft water system with acceptable phosphorus levels.

PLANKTON

The plankton are microscopic organisms which inhabit the open waters of a lake or pond. This term includes both plants and animals - phytoplankton and zooplankton.

Phytoplankton

Phytoplankton are microscopic algae which swim or float in the open water. Dense populations of phytoplankton can color the water green and increase turbidity. Total numbers of phytoplankton were generally low during both studies. The dominant algae were the nannoplankton, a collective group of tiny algal cells too small to identify with any certainty. These algae comprised about 83% of the total phytoplankton present in 1995, and about 61% in 2006. Nannoplankton are often dominant in low nutrient lakes.

Euglenas, dinoflagellates, cryptomonads and many chrysophyte species are unicellular algae that swim actively through the water by means of whip-like flagella, and are collectively termed flagellates. Aside from nannoplankton, the flagellates were the most common phytoplankton in the lake, comprising 15.5% of the total in 1995 (Appendix A) and 24.9% in 2006 (Table 3). Such swimming forms are frequently important in lakes dominated by floating leaved plants such as water lilies. They are able to swim actively toward the surface and take advantage of small patches of light between the lily pads.

Chlorophyll a is a green pigment specific to plants and algae. It is used as a by-weight indicator of phytoplankton biomass in a lake. In June 1995, chlorophyll a was quite high at about 14.9 μg/l, due to a short term bloom of nannoplankton (over 11,000 organisms per ml). During all other sampling occasions, chlorophyll a was low in the lake ranging from 2.2 μg/l to 5.6 μg/l, and thus was within the early mesotrophic range.

Zooplankton

Zooplankton were included in the 2006 study as part of the broad characterization of the lake. They are minute swimming animals which graze on bacteria, phytoplankton and small particles of organic matter. They range in size from microscopic protozoa and rotifers, which are about the size of phytoplankton, to cladocerans and copepods, some of which are large enough to be seen without a microscope. Illustrations of zooplankton showing examples

HIDDEN LAKE
Haddam, CT **PHYTOPLANKTON 2006**
(Organisms per milliliter)

Group	Genus	Jun 12	Jul 14	Aug 10	Group Means	Percent Total
Bluegreen Algae					9	0.85%
	Chroococcus		9			
	Merismopedia		19			
Green Algae					56	5.10%
	Eudorina	38	9			
	Golenkinia		19			
	Oocystis	9	19			
	Scenedesmus	9	19	19		
	Tetraedron	9		19		
Euglena					53	4.83%
	Euglena		19			
	Trachelomonas	47	38	56		
Dinoflagellates					50	4.53%
	Peridinium	19	47	66		
	Gymnodinium		9	9		
Chrysophytes					9	0.85%
	Mallomonas		9	19		
Cryptomonads					163	14.73%
	Cryptomonas	94	131	263		
Diatoms					94	8.48%
	Fragillaria	56	104	47		
	Navicula	9	19	9		
	Nitzschia			9		
	Synedra		9	19		
Nannoplankton		169	535	1305	670	60.64%
Totals		459	1014	1840	1104	100%

of the various groups are provided courtesy of the Department of Zoology, Center for Freshwater Biology, University of New Hampshire, Durham, NH (Figure 2). Zooplankton form the food base for many fish species, especially juveniles.

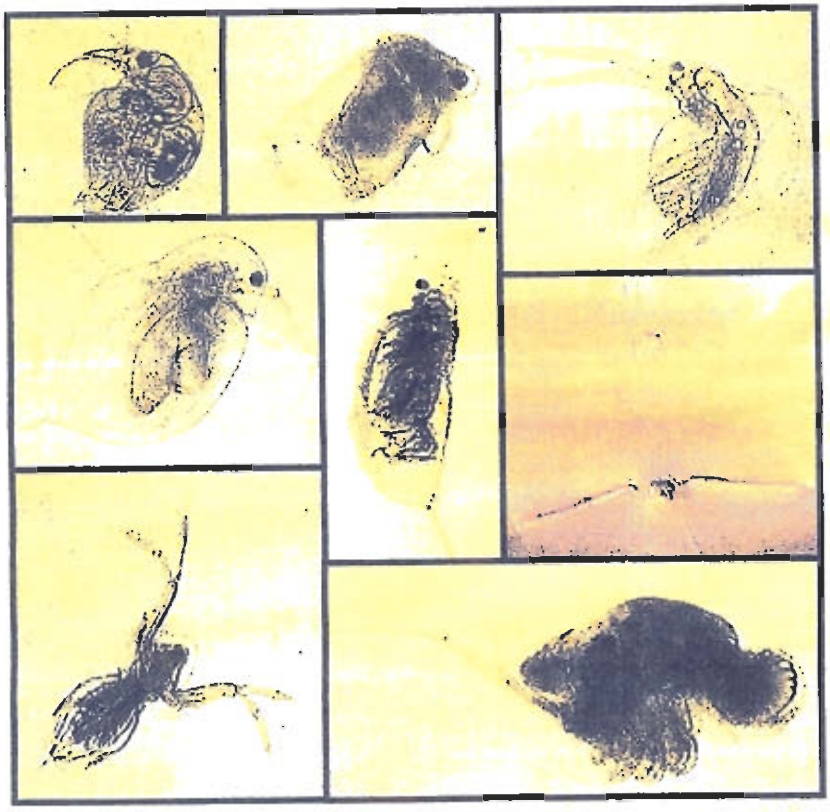
Rotifers form a large class of zooplankton with many species. All are filter feeders, using a ring or cluster of cilia (short filaments) to waft bacteria and other organic particles into their mouths.

Cladocerans, commonly known as water fleas, are much larger than rotifers. They are barely visible as tiny particles in a water sample. Under the microscope they have a distinct head, a double sided shell, large compound eyes and spiny appendages for swimming. They are also filter feeders, using large mandibles to grind their food.

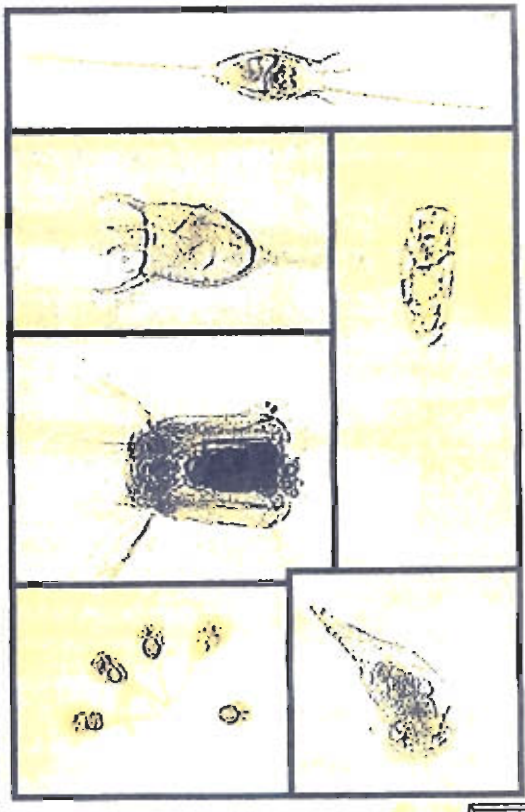
Copepods are generally larger than cladocerans and are almost insect-like in appearance. The body is divided into a head region with antennae and mouth parts, a thorax with six pairs of legs for swimming and a bifurcated tail structure. Copepods do not filter-feed but are raptors, actively seeking and grasping their food. The larger species may be predatory, feeding on smaller zooplankton, but other species are herbivorous, feeding exclusively on algae. Copepods are made visible in a water sample by their jerky irregular movements.

Zooplankton are often collected by pulling a net vertically from a known depth to the surface. In this way, a column of water is sampled with a specific volume, and the density (expressed as the number of animals per liter of lake water) can be calculated. Since Hidden Lake is too shallow for a vertical tow, the net was pulled horizontally near the surface for several minutes. This qualitative sampling method gives a list of species present, and the counts (expressed as percent total) indicate the relative abundance of the major groups on each sampling occasion (Table 4).

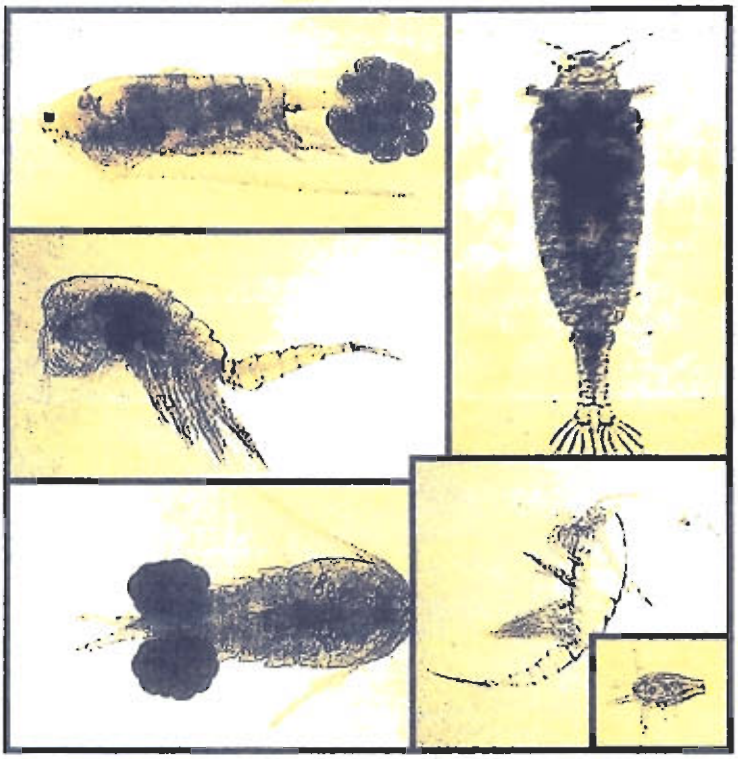
Figure 2, Zooplankton Groups



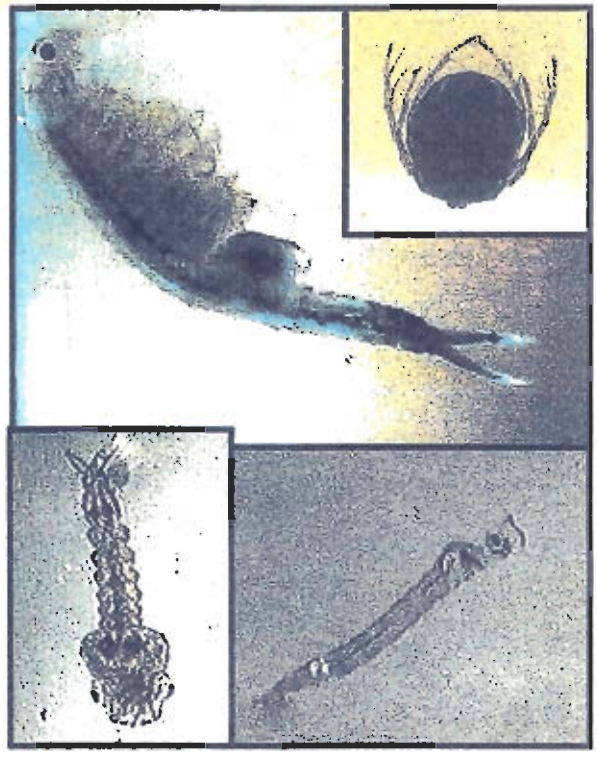
Cladocera



Rotifera



Copepoda



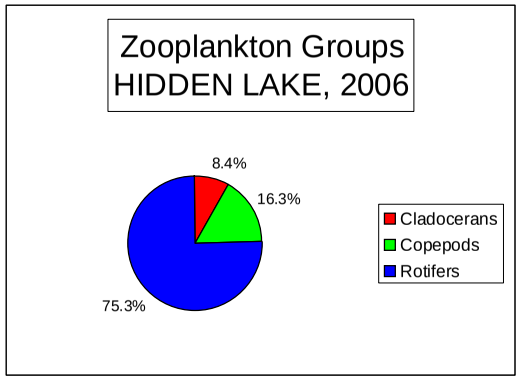
Arthropoda

HIDDEN LAKE **ZOOPLANKTON**
Haddam, CT Summer, 2006

Order	Family	Genus/Species	June Occurrance	July Occurrance	August Occurrance	June % Total	July % Total	August % Total	Summer % Total
Cladocerans						**19.4%**	**0.9%**	**4.9%**	**8.4%**
	Daphnidae	*Bosmina*	X	X	X				
		Daphnia	X						
Copepods						**25.8%**	**6.3%**	**16.9%**	**16.3%**
		Nauplius larvae	X	X	X				
	Cyclopoida	Unidentified clyclopid copepod		X	X				
Rotifers						**54.8%**	**92.8%**	**78.2%**	**75.3%**
		Asplanchna	X	X	X				
		Collotheca	X	X	X				
		Conochiloides			X				
		Gastropus	X	X	X				
		Keretella	X	X	X				
		Polyartha			X				
		Trichocera		X	X				
		Total Number of Genera	**7**	**8**	**10**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Table 4. Zooplankton

		Pattern	Color
8.4	Cladocerans	2	1
16.3	Copepods	**3**	**1**
75.3	Rotifers	4	1



Zooplankton diversity in Hidden Lake was similar from month to month, ranging from 7 to 10 species. The principal zooplankters included rotifers (about 75% of the total present throughout the study), copepods (about 16%) and cladocerans (about 9%). Cladocerans and copepods were generally most abundant in June and August. Rotifers were important all three months, but most numerous in July due to a bloom of the rotifer *Keretella*. The dominance of rotifers would be expected in a lake with abundant small prey such as nannoplankton.

AQUATIC PLANTS

As noted above, a plant distribution study of Hidden Lake was carried out by CAES in 2005 as part of a state wide survey for invasive species. A plant map was developed, together with plant density and water quality data (Appendix B). A final report is presently in preparation. The 2005 study included 4 transects, one from the west shore toward the center of the lake, and the others from the shore to open water in North Cove, South Cove and West Cove (Figure 1). In addition to 13 aquatic plant species, 5 semi-aquatic wetland species were recorded along the lake edge.

The aquatic plant surveys in 1995 and 2006 were carried out by traversing the length of the entire shoreline and observing the plants with a bottom viewer. Between the three studies a total of 24 plants have been identified, none of which is an invasive species (Table 5). In all the surveys, three floating-leaved varieties were dominant: white water lily, yellow pond lily and watershield. As the summer progressed, these floating leaved plants formed dense mats, especially in North Cove, West Cove and Mill Bay (Photographs 1 and 2). Other plants with floating leaves included little floatingheart, floating pondweed and snailseed pondweed. Wild celery, elodea and the pondweeds produce small flowers and seed heads which also reach the surface. Naiad, stonewort and the various bladderworts remain below the surface. Low watermilfoil *Myriophyllum humile* found in 1995 is a native plant which, unlike several other watermilfoil species, is not considered invasive (Mehrhoff, et al. 2003).

Table 5. Aquatic Plants

HIDDEN LAKE
Haddam, CT **AQUATIC PLANTS**

Scientific Name	Common Name	Habitat	2006	2005	1995
Brasenia schreberi	Watershield	Aquatic	X	X	X
Elatine minima	Waterwort	Shore		X	
Eleocharis acicularis	Slender Spikerush	Shore		X	
Elodea canadensis	Common elodea	Aquatic			X
Gratiole aurea	Goldenpert	Shore		X	
Isoetes engelmannii	Quillwort	Shore		X	
Myriophyllum humile	Low watermilfoil	Aquatic			X
Najas flexilis	Naiad	Aquatic		X	
Nitella spp.	Stonewort	Aquatic		X	X
Nuphur luteum	Yellow pond lily	Aquatic	X	X	X
Nymphaea odorata	White waterlily	Aquatic	X	X	X
Nymphoides cordatum	Little floatingheart	Aquatic	X		
Pontederia cordata	Pickerelweed	Shore	X	X	
Potamogeton biculpatus	Snailseed pondweed	Aquatic		X	
Potamogeton epihydrus	Ribbonleaf pondweed	Aquatic	X	X	X
Potamogeton foliosus	Leafy pondweed	Aquatic			X
Potamogeton natans	Floating pondweed	Aquatic	X	X	X
Potamogeton pusillus	Slender pondweed	Aquatic			X
Utricularia spp.	Bladderwort	Aquatic			X
Utricularia intermedia	Flatleaf bladderwort	Aquatic		X	
Utricularia purpurea.	Purple bladderwort	Aquatic	X	X	
Utricularia radiata	Little floating bladderwort	Aquatic	X	X	
Utricularia vulgaris	Common bladderwort	Aquatic	X	X	
Vallisneria americana	Wildcelery	Aquatic	X	X	X
	Total - 24 Species		**11**	**18**	**12**

Photograph 1: Taken 6/12/06 from Hidden Lake Road looking north across South Cove. Floating leaved plants are beginning to reach the surface.

Photograph 2: Taken 8/10/06 from Hidden Lake Road looking north across South Cove. Shows the fully developed dense community of aquatic plants.

The absence of invasive plants is an extremely important feature of Hidden Lake. The CAES investigators did a very thorough search of the lake and found none. Only a few lakes in the state remain free of these weeds. The 1995 report discussed characteristics of Eurasian water-milfoil, *Myriophyllum spicatum*, and included an illustration. However, two other invasive species are now widespread in Connecticut Lakes and are seriously affecting recreation: variable-leaf water-milfoil *Myriophyllum heterophyllum*; and fanwort *Cabamba caroliniana*. These plants form dense bushy growth up to and across the surface, interfering with boating and fishing activities. They reproduce primarily by fragmentation, and are carried from lake to lake on motors and boat trailers. Upon reaching a lake, the plant fragments take root and can spread throughout the lake within a few years. They tend to fill in rapidly where native plants have been removed by harvesting or herbicide applications.

Other invasive species include curlyleaf pondweed *Potamogeton crispus;* the naiad *Najas minor*, and water chestnut *Trapa natans*. Curlyleaf is a spring form which dies back early in the summer. Naiad grows prolifically but remains near the bottom. Water chestnut has floating leaves and produces many large spiny seeds which curtail swimming activities. Thus far, it is not widespread in the state.

RECOMMENDATIONS

The 1995 report discussed a variety of recommendations, all of which are still valid. The report can be found on the Hidden Lake Association web page (www.hiddenlakect.org). Management recommendations within the watershed included maintenance of septic systems, reduction of fertilizers, discouragement of Canada geese, prevention of soil erosion and limitation of additional beach sand. Discussions of in-lake plant management measures included grass carp (not recommended), herbicides, benthic barriers, plant harvesting and winter drawdown. Other possible options included aeration and dredging.

Existing Association Programs

The Hidden Lake Association has instituted a number of important lake and watershed management efforts suggested in the 1995 report. The importance of such ongoing vigilance and proactive measures cannot be over emphasized.

Stormwater

A engineering drainage report identified problems with stormwater, soil erosion and sedimentation in four major areas around the lake (HRP Associates, Inc., 2002). The Lake Association has since developed a program for cleaning the surrounding catch basins every year. However, based on the report's recommendations, there are many areas immediately around the shore which need extensive remediation. Since phosphorus reaches a lake bound to soil particles carried in by stormwater, it is important that the Association continue these efforts and make plans for future repairs and maintenance. Engineering advice will be required to prioritize the work for maximum cost effectiveness. Help from the town should be sought where appropriate.

Septic System Maintenance

Another very important innovation sponsored by the Lake Association is the septic system maintenance program. Septic systems around the lake are pumped out regularly on a three year cycle. Routine septic system maintenance and repair is critical in controlling the flow of nutrients in the groundwater, especially considering the number of homes clustered on slopes around the lake (Figure 1). Garbage disposal waste should not be released to a septic system, nor should such household chemicals as bleach or other strong cleaning agents. The concentration of phosphorus in detergents is extremely high and only non-phosphate varieties should be used. This measure alone can reduce the amount of phosphorus reaching the groundwater around a septic system by 30% to 40%.

Home and Property Maintenance

It is also important that homeowners be aware of other sources of nutrients which may originate on their property. Soil erosion can occur due to lawn replacement, gardening activities, construction, uprooted trees during storms, etc. Any areas of open soil should be surrounded by silt fence or hay bales and stabilized with mulch until vegetative cover can be established. Residents in the vicinity of the lake should be urged not to have liquid fertilizers applied to their lawn. Only slow release types designed for lakeside lawns should ever be used. Lawn and garden herbicides and pesticides should be used sparingly, or not at all. Cars, lawn furniture, etc. should be washed in grassy areas. This will ensure that the wash water will filter through vegetation into the soil rather than flow into a storm drain or stream leading to the lake. Power washing a house with high phosphate detergent can release significant phosphorus to the environment.

Enteric Bacteria Testing

For many years the Association has been conducting tests during the summer to determine the safety of the water for swimming. Samples are collected at East Shore Beach, West Shore Beach and Shore Beach. Samples are also collected in North Cove, West Cove, South Cove and Mill Cove. The tests include fecal coliform and E. coli bacteria, together with nitrate, nitrite and total phosphorus.

Other Existing Programs

The Association has developed an internet web page to disseminate information to members (www.hiddenlakect.org). Bacterial testing results and various lake reports are posted on this site. Communication by e-mail is also an important tool. Participation by all of the neighborhood residents is essential for protecting the lake.

Tree stumps were removed from West Cove and South Cove to improve boating and fishing. The lake was stocked with 125 large mouth bass.

Aquatic Plants

It is important to recognize that Hidden Lake is a very shallow system, given its surface area. The average depth is only about 5 to 6 ft. The bottom is soft unconsolidated sediment except for a few sandy areas. The water, although stained, is clear, and light reaches to the bottom. These conditions are ideal for plant growth. The density of plants is a natural feature of the lake and does not indicate impairment. Also, the plants are an essential component of the lake, adding oxygen to the water, sequestering nutrients and providing food and habitat for fish. From the perspective of recreation, however, plants interfere with boating, fishing and swimming. Short of extensive dredging, there is no way to reduce the plant population permanently. Unfortunately, a possible side effect of plant control, especially harvesting, is the importation of invasive plants which would quickly replace the community of removed native species. Plant management should always be approached with caution, patience and the realization that all control measures are temporary.

Hydroraking and Plant Cutting

Hydroraking is a means of removing water lilies, by digging out the very large rhizomes which anchor the plants in the sediments and store nutrients over the winter months. About three years ago, the lilies in West Cove were hydroraked. The population was considerably reduced at the time, but the plants have already recovered. Hydroraking can be continued, but is expensive and presents the possibility of introducing invasive plants.

The Lake Association carried out a pilot plant cutting program in early August, 2006, using a Jenson Lake Mower mounted on a John boat with an electric trolling motor. The newly purchased equipment will be used only in Hidden Lake, thus eliminating the invasive plant issue. A 40 ft wide area was cut along the west shoreline of South Cove extending

from the beach to Hidden Lake Road. As of the August 10 sampling trip, the area appeared quite well cleared with occasional severed plants floating on the surface. Cut plants should be raked out the water as much as possible, and removed from the shoreline. This method offers some relief, but is labor intensive and is best limited to fairly small areas.

Draw down

The by-laws of the Association require that the lake be drawn down to allow for the repair of docks and other shoreline structures. The lake is drawn down every other year between October 1 and January 1, and the basin refills quickly in the spring. When a lake is drawn down during the winter, many soft bodied plants, including *Potamogeton* species, die back due to drying and freezing. The heavy leaves, stems and rhizomes of water lilies are less affected. The success of drawdown for plant control depends on the severity of a particular winter. Drawdown has lake-wide impacts. Shoreline and bottom invertebrates will be adversely affected. However, water levels in lakes vary naturally from year to year and, in general, drawdown is a benign method of plant control. Plants and animals surviving under water off shore will eventually move back into the near shore areas. Since the drawdown of Hidden Lake is an ongoing program, it is possible that plants resistant to freezing and drying have already been selected for, and that the effectiveness of the method may be decreasing with time.

Herbicides

Lake wide use of herbicides is not recommended. Masses of dead plants decompose in the lake and oxygen depletion can result. Fish shelter and breeding habitat is lost. However, because of plant density, access to open water is restricted in front of many of the shoreline residences. Small scale use of appropriate herbicides could be carried out in specific limited areas, with the understanding that chemical applications provide only temporary control. A pesticides permit from the CTDEP is required. Herbicides must be applied by a licensed professional who will recommend the most appropriate chemical and

calculate the needed concentration. As with harvesting, invasive plants can be introduced into the lake on boats used for chemical applications.

Invasive Plant Control

CAES has recently published a useful bulletin, "A Guide to Invasive Aquatic Plants in Connecticut" which describes the plants in detail and contains photographs to aid in identification (CAES, 2005). Assistance is offered regarding recognition and control of invasive species. It is recommended that the Association form a watch committee of a few residents willing to undertake training by CAES, to check the lake for newly arrived plants, and to educate boaters using their craft in other lakes. Inspection of the lake must be ongoing. If any of the plants are found, CAES should be contacted for advice concerning immediate eradication.

Other Options

Other management techniques, including benthic barriers, aeration and dredging, are described in the 1995 report. Benthic barriers have proved to be useful in other lakes for keeping small areas free of weeds. Their value for water lily control is limited. The barriers must be raised and cleaned about every two years to maintain effectiveness. This could be accomplished rather easily during the period of drawdown. It might be appropriate to experiment with barriers at the Association beaches.

Aeration fountains are used in lakes to increase oxygen and circulate the water. High oxygen concentrations tend to sequester nutrients in the bottom sediments and thereby reduce algal populations (anaerobic sediments release nutrients to the overlying water). Aeration has no effect on plant life. Current data support the conclusion in the 1995 report that oxygen levels are naturally adequate in this lake and aeration is not indicated. Aeration systems are expensive to buy, install and operate, especially in a water body as large as hidden lake.

Dredging could be investigated as a long term solution to the weeds in this lake. In some instances, valuable deposits of sand or gravel under a lake can be used to defray the cost of dredging. Cores are taken to determine the composition of the underlying material. Without such resources, however, the cost of large scale dredging is beyond the financial capabilities of most lake associations.

SUMMARY

The 2006 study indicates that the condition of Hidden Lake has not changed significantly since 1995. Oxygen levels are adequate to sustain fish and other aquatic animals. Conductivity, alkalinity and pH are within the range expected for a soft water lake. The water is clear but very dark in color due to the presence of natural humic substances. Phytoplankton numbers and levels of chlorophyll a (phytoplankton biomass) are moderate to low. The zooplankton community is dominated by small forms, especially rotifers. Total nitrogen, total phosphorus and chlorophyll a levels indicate that the lake is mesotrophic. This classification has not changed since 1995. The majority of lakes in Connecticut fall within the mesotrophic range. Hidden Lake is shallow and an abundance of aquatic plants naturally results from this characteristic. Plant surveys in 2006 and 1995, together with a 2005 study by the Connecticut Agricultural Experiment Station, indicate the presence of a large number of plant species. Diverse beds of aquatic plants are important to lake ecology, providing food and cover to amphibians, reptiles and fish. However, floating leaved plants in many areas of Hidden Lake have become dense, affecting its appearance and recreational value. A plant management program should include the continuation of winter drawdown, together with the possible small scale use of chemicals and limited plant cutting in specific areas. Although Hidden Lake is shallow with an abundance of plants, it remains a vigorous and stable ecosystem.

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APPENDIX A

1995 WATER QUALITY AND PHYTOPLANKTON DATA

HIDDEN LAKE
Haddam, CT

PHYSICAL CHEMICAL CHARACTERISTICS
STATION 1
1995

June 27, 1995
Weather: Bright sun, very windy
Secchi: 1.68 m
Depth: 1.80 m
Time: 0855

Depth meters	Temp. oC	D.O. mg/l	Conduct. umhos/cm	pH	Alkal. mg/l	NO3-N mg/l	T.P. mg/l	Chloro.a ug/l	Phaeo.a ug/l
Surface	22.8	7.8	63	6.93	15	BDL	0.013	14.890	3.740
0.5	22.8	6.9	63						
1.0	22.8	6.9	63						
1.5	22.8	6.9	63						
Bottom	22.8	4.5	75						

July 20, 1995
Weather: Clear, scattered clouds, surface calm
Secchi: To Bottom
Depth: 1.66 m
Time: 0820

Depth meters	Temp. oC	D.O. mg/l	Conduct. umhos/cm	pH	Alkal. mg/l	NO3-N mg/l	T.P. mg/l	Chloro.a ug/l	Phaeo.a ug/l
Surface	25.8	8.2	68	7.20	15	BDL	0.016	5.050	2.780
0.5	25.8	8.2	69						
1.0	25.8	8.2	69						
1.5	25.1	6.4	69						
Bottom	25.1	3.8	72						

August 26, 1995
Weather: Full sun, mild, calm
Secchi: To Bottom
Depth: 1.70 m
Time: 0840

Depth meters	Temp. oC	D.O. mg/l	Conduct. umhos/cm	pH	Alkal. mg/l	NO3-N mg/l	T.P. mg/l	Chloro.a ug/l	Phaeo.a ug/l
Surface	22.0	7.4	69	7.19	15	BDL	BDL	2.180	1.620
0.5	22.0	7.4	69						
1.0	22.0	7.6	69						
1.5	22.0	7.5	69						
Bottom	22.0	6.9	70						

ABBREVIATIONS:

oC = Degrees Celsius
mg/l = Milligrams/liter
ug/l = Micrograms/liter
umhos/cm = Micromhos/centimeter
Temp. = Temperature
D.O. = Dissolved Oxygen
Conduct. = Conductivity
Akal. = Alkalinity
Chloro. = Chlorophyll a
Phaeo. = Phaeopigment a
NO3-N = Nitrate Nitrogen
NO2-N = Nitrite Nitrogen
NH4-N = Ammonia Nitrogen
T.O.N. = Total Organic Nitrogen
T.N. = Total Nitrogen
T.P. = Total Phosphorus

HIDDEN LAKE
Haddam, CT

PHYTOPLANKTON 1995
(Organisms per milliliter)

Group	Genus	June 27	Jul 20	Aug 26	Group Means	Percent Total
Bluegreen Algae					31	0.61%
	Chroococcus		9			
	Oscillatorya			75		
	Polycystis			9		
Green Algae					21	0.42%
	Ankistrodesmus	9				
	Pediastrum		9			
	Scenedesmus			9		
	Tetraedron		28	9		
Euglena					13	0.25%
	Trachelomonas	19		19		
Dinoflagellates					291	5.77%
	Ceratium		9			
	Peridinium	460	254	19		
	Gymnodinium	28	38	66		
Chrysophytes					156	3.10%
	Dinobryon	141	28			
	Mallomonas	56	19			
	Synura		169	56		
Cryptomonads					319	6.33%
	Cryptomonas	423	150	38		
	Rhodomonas	178	56	113		
Diatoms					3	0.06%
	Navicula		9			
Nannoplankton		10536	1427	667	4210	83.45%
Totals		11850	2205	1080	5045	100%

APPENDIX B

2005 AQUATIC PLANT MAP AND WATER QUALITY DATA

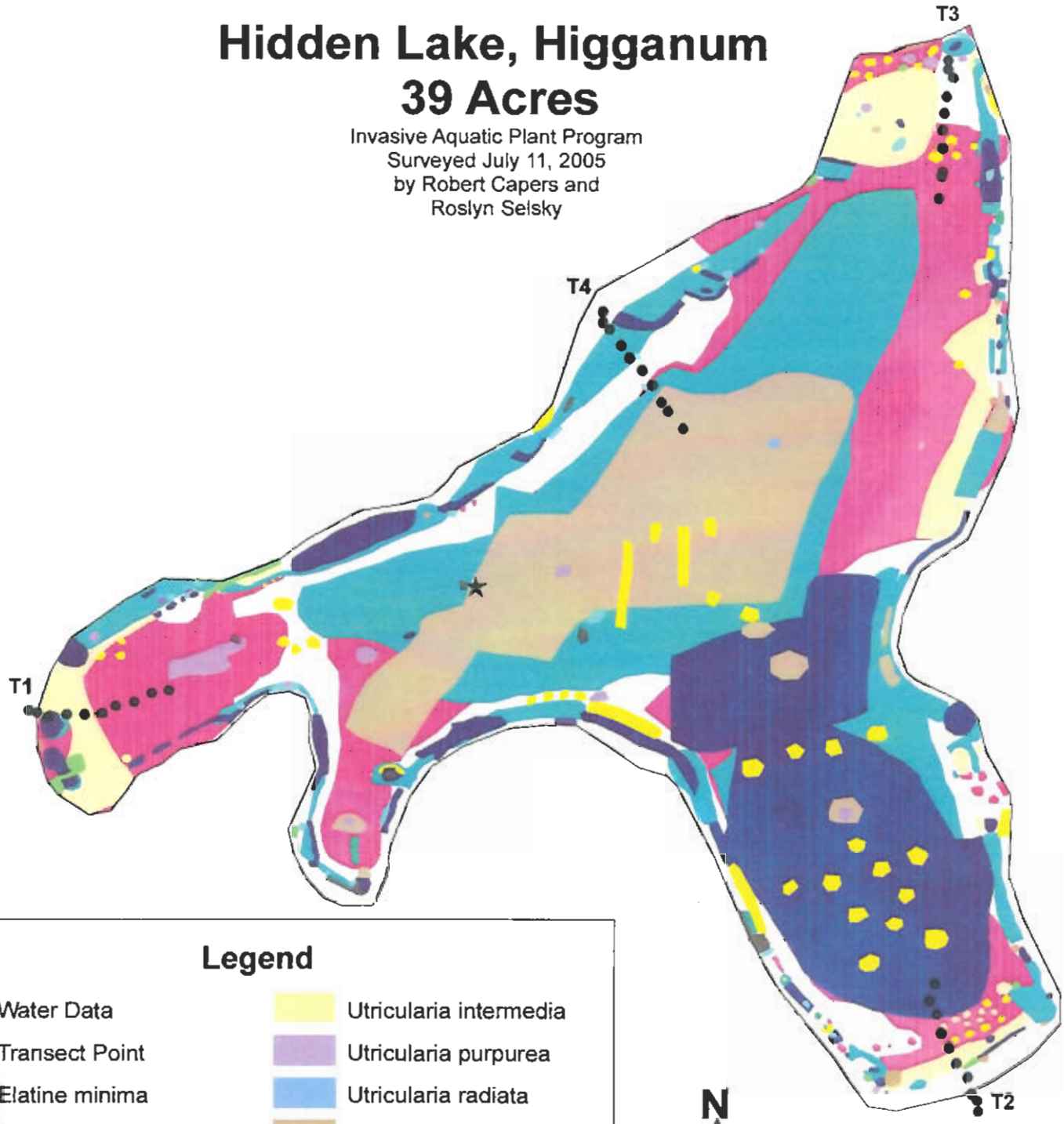
Connecticut Agricultural Experiment Station

Invasive Aquatic Plant Program

New Haven, CT

Hidden Lake, Higganum
39 Acres

Invasive Aquatic Plant Program
Surveyed July 11, 2005
by Robert Capers and
Roslyn Selsky



Legend

- ★ Water Data
- • Transect Point
- Elatine minima
- Eleocharis acicularis
- Gratiola aurea
- Isoetes engelmannii
- Nuphar variegata
- Potamogeton bicupulatus
- Potamogeton natans
- Pontederia cordata
- Utricularia intermedia
- Utricularia purpurea
- Utricularia radiata
- Utricularia vulgaris
- Potamogeton epihydrus
- Charaphyte
- Najas flexilis
- Vallisneria americana
- Brasenia schreberi
- Nymphaea odorata

N

0 95 190 380 570 760 Feet

Water Tests
Hidden Lake

Depth	DO	Temp
0.5	7.2	28
1	8	27.7
2	5.3	27.5

Weather	Latitude*	Longitude	Depth (m)	Dissolved Oxygen (mg/L)	Temperature (°C)
sunny	41.42103	-72.57104	0.5	7.2	28
			1	8	27.7
			2	5.3	27.5

GPS_Date	Latitude	Longitude
7/11/2005	41.42103	-72.57104

Secchi	Depth
1.9	1.9

Depth (m)	Conductivity (µs/cm)	pH	Alkalinity expressed as Calcium carbonate (mg/L)	Phosphorus (parts per billion)
0.5	72.4	5.6	6	23
1.5	79.2	5.7	7.5	14

APPENDIX C

2006 WATER QUALITY DATA REPORTS

Prepared by

Connecticut Testing Laboratories, Meriden, CT

Date Samples Received: 6/13/06

Client Name :	**Marine & Freshwater Research**	CTL Lab No. :	0606186
Report Date :	6/28/06	PO/ Job No. :	Hidden Lake

RESULTS OF ANALYSIS

Matrix Type :	**W**
CTL Sample No.	**10251**
Field ID :	**Hidden Lake**

Parameters	**MDL**				
Nitrate-N-mg/L	0.010	BDL			
Nitrite-N-mg/L	0.002	0.005			
Ammonia-N-mg/L	0.010	0.015			
Tot. Organic Nitrogen-mg/L	0.010	0.112			
Tot. Phosphorus-P-mg/L	0.010	0.010			

Matrix Types : W= Water/Aqueous **S=** Soil/Solid **O=** Oil / Hydrocarbon

MDL= Method Detection Level / **BDL=** Below Detection Level

Connecticut Testing Laboratories, Inc.
165 Gracey Avenue / Meriden, CT 06451
(203) 634-3731 (Fax) 630-1336
Certification CT-PH0547/ MA-CT035

Date Samples Received: 8/09/06

Client Name :	**Marine & Freshwater Research**	CTL Lab No. :	0806149
Report Date :	8/23/06	PO/ Job No. :	NA

RESULTS OF ANALYSIS

Matrix Type : **W**
CTL Sample No. **14140**
Field ID : **Hidden Lake**

Parameters	MDL				
Nitrate-N-mg/L	0.010	0.010			
Nitrite-N-mg/L	0.002	0.014			
Ammonia-N-mg/L	0.010	0.056			
Tot. Organic Nitrogen-mg/L	0.010	0.637			
Tot. Phosphorus-P-mg/L	0.010	0.010			

Matrix Types : W= Water/Aqueous **S=** Soil/Solid **O=** Oil / Hydrocarbon

MDL= Method Detection Level / **BDL=** Below Detection Level

Connecticut Testing Laboratories, Inc.
165 Gracey Avenue / Meriden, CT 06451
(203) 634-3731 (Fax) 630-1336
Certification CT-PH0547/ MA-CT035

Date Samples Received: 7/14/06

Client Name :	**Marine & Freshwater Research**	CTL Lab No. :	0706199
Report Date :	7/27/06	PO/ Job No. :	Hidden Lake

RESULTS OF ANALYSIS

Matrix Type : **W**
CTL Sample No. **12411**
Field ID : **Hidden Lake**

Parameters	MDL				
Nitrate-N-mg/L	0.010	0.100			
Nitrite-N-mg/L	0.002	0.005			
Ammonia-N-mg/L	0.010	0.020			
Tot. Organic Nitrogen-mg/L	0.010	0.579			
Tot. Phosphorus-P-mg/L	0.010	0.020			

Matrix Types : **W=** Water/Aqueous **S=** Soil/Solid **O=** Oil / Hydrocarbon

MDL= Method Detection Level / **BDL=** Below Detection Level

Connecticut Testing Laboratories, Inc.
165 Gracey Avenue / Meriden, CT 06451
(203) 634-3731 (Fax) 630-1336
Certification CT-PH0547/ MA-CT035

GLOSSARY OF ECOLOGY TERMS

Alga, (pl. Algae): a group of simple primitive plants (without roots, stems or leaves) that live in wet and damp places. In lakes they are mostly microscopic in size.

Alkalinity: concentration of dissolved compounds that collectively shift the pH toward the alkaline side of neutrality. Measured as the concentration of calcium carbonate.

Anaerobic (same as anoxic): without oxygen

Aquatic plant: a vascular plant living partially or totally underwater

Biomass: the amount of living material, by weight, found within a given area at a given time

Bloom: an abundant development of phytoplankton

Blue green algae: a large group of bacteria-like algae of the class Cyanophyceae. These organisms are often prevalent in lakes during the warm summer months. Some species form noxious blooms in eutrophic lakes.

Celsius (abbrev. ^{o}C): a measure of temperature. Examples: (freezing point of water) 32 ^{o}F = 0 ^{o}C; (room temperature) 70 ^{o}F = 21^{o}C

Centimeter (abbrev. cm): 1/100 of a meter. 1 inch = 2.54 cm

Chlorophyll a: the main plant pigment used in photosynthesis

Chrysophytes: the algal class known as the Chrysophyceae. A diverse group of unicellular and colonial forms, many of which are motile. They are often golden brown in color and share a certain specific set of pigments.

Conductivity: a measure of the overall ionic content of the water based on its ability to conduct a current.

Cryptomonads: an algal class known as the Cryptophyceae. They are small unicellular swimming forms very common in lakes.

Data: measurements

Diatoms: a large and diverse group of algae belonging to the Chrysophyceae. Their unique characteristic is a silica cell wall (a shell of glass). Some diatoms float and others are motile and glide across surfaces.

Dinoflagellates: a group of animal-like swimming algae belonging to the class Pyrrophyceae. Several species are important in Connecticut lakes.

Dominant: the most abundant species in a lake at one time

Drawdown: a deliberate lowering of the lake level

Ecosystem: a community of organisms together with the environment in which they live and with which they interact

Eutrophic: nutrient rich and having high levels of algal and plant growth

Fertility: level of enrichment

Flagellum (pl. flagella): a whip-like structure which is used by motile algae (flagellates) for swimming.

Fluorometer: an instrument used to measure the fluorescence of chlorophyll a.

G.P.S.: Geographic Positioning System

Genus (pl. genera): a group of closely related species

Gram (abbrev. gm): the weight of a milliliter of water (a small thimbleful)

Green algae: a diverse group of algae belonging to the class Chlorophyceae. They can reach bloom proportions in enriched lakes and ponds.

Kilo-: 1000. examples: 1 kilogram = 1000 grams (about 0.5 lb). 1 kilometer = 1000 m (about 6/10 mi)

Limnology: the study of lakes and other freshwater systems

Liter (abbrev. L): a measure of volume. 1 gallon = 3.8 liters

Lugol's Solution: an iodine solution used to stain and preserve phytoplankton

Mean: average

Mesotrophic: moderate nutrient levels

Meter (abbrev. m): a measure of length. 1 yard = about 0.91 m

Micro-: 1/1,000,000. Example: 1 microgram (abbrev. μg) = 1 millionth of a gram

Milli-: 1/1000. Examples: 1 milligram (abbrev. mg) = 1 thousandth of a gram. 1 milliliter (abbrev. ml) = 1 thousandth of a liter

Nannoplankton: very small phytoplankton

Nitrate: one of several nitrogen compounds that are important in the nutrition of plants

Nutrient: any chemical element, ion or compound that is required by organisms for growth

Oligotrophic: nutrient poor

Organic: pertaining to living matter

pH: the degree of acidity. A pH of 7 is neutral, under 7 is acidic and over 7 is alkaline

Phaeopigment a: breakdown product of chlorophyll a

Phosphorus: the most important nutrient for plant and algae growth in lakes

Photosynthesis: metabolic process by which plants and algae trap light and use its energy to manufacture energy rich compounds (such a sugars) from energy poor compounds (carbon dioxide and water)

Phytoplankton: microscopic free floating or swimming algae in a lake

Profile: data from a vertical line of samples taken from the lake surface to the bottom

Rhizome: modified stem that grows underground.

Rose Bengal: used with alcohol to stain and preserve microorganisms. Allows differentiation of living animals from plants and detritus

Secchi disk: a standard size weighted white disk which is lowered into the water until it disappears from view. Gives a measure of water transparency

Species: a category of organisms having common attributes and designated by a common name

Total nitrogen (abbrev. TN): the total amount of nitrogen in a lake, consisting of nitrate, nitrite, ammonia and organic nitrogen

Trophic status: level of fertility

μmhos: abbreviation of micromhos, the conductivity unit of measure

Unicellular: describing an organism consisting of a single cell. Usually a bacterium, alga or protozoan

Watershed: the area surrounding a lake from which water drains ultimately into the lake

Water column: water from surface to bottom in a specific area of the lake

Wetland: a semi-terrestrial area characterized by poorly drained mottled soil and a community of water tolerant plants

Variable: a characteristic that can be measured and whose value varies in time and space

Zooplankton: microscopic animals inhabiting the open water