LAKESHORE ENVIRONMENTAL, INC.
SCIENTISTS · ENGINEERS · PLANNERS

AN AQUATIC VEGETATION SURVEY OF PARADISE LAKE, EMMET AND CHEBOYGAN COUNTIES, MICHIGAN

JULY, 2009

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July, 2009

1.0 EXECUTIVE SUMMARY

This report describes the current aquatic vegetation communities within Paradise Lake (Figure 1), a 1,912-acre, shallow, eutrophic lake with a maximum depth of 17 feet (Michigan State University, Department of Fisheries and Wildlife, 1989). Paradise Lake is located in sections 7, 18, 10-15, 23, and 24 of Emmet and Cheboygan Counties (T.38N, R. 3,4W). In recent years, the lake has become colonized with zebra mussels (*Dreissena polymorpha*), which has allowed increased light transparency to penetrate the waters of the lake, and accelerates growth rates of all aquatic vegetation, including the exotic submersed aquatic plant, Eurasian Watermilfoil (*Myriophyllum spicatum*). *M. spicatum* has become a threat to the native aquatic vegetation communities within Paradise Lake, severely impedes navigation and recreational activities within the lake, creates a swimming hazard in areas of dense canopy growth, and decreases lakefront property values.

This survey conducted by aquatic scientists at Lakeshore Environmental, Inc during July of 2009, consisted of 609 grid sampling locations located throughout Paradise Lake and determined that approximately 497 acres of *M. spicatum* exists in the lake. At each sampling location, a WAAS-enabled 50-satellite capacity GPS unit with an accuracy of 2.0 feet was used to accurately record geo-referenced data. At each grid point two rake tosses were conducted and all species and relative abundance of rake specimens collected were recorded. This method, also known as the Point-Intercept Method for aquatic vegetation sampling, is used widely among aquatic scientists to sample large aquatic ecosystems in an unbiased manner. The U.S. Army Corps of Engineers utilizes this methodology for pre-treatment and post-treatment surveys to assess the efficacy of lake improvement programs. This type of survey is also amenable to statistical analysis, which is instrumental in measuring the success of any improvement protocol such as biological control, aquatic herbicides, or a combination of these two methods. Regular rigorous GPS Point-Intercept aquatic plant surveys utilizing this protocol are critical for the detection of exotic species such as *M. spicatum*, which may limit more favorable, native aquatic plants and consequently alter the ecological balance and biotic integrity of aquatic ecosystems.

Overall management recommendations for the control of *M. spicatum* in Paradise Lake include spot-treating *M. spicatum* with EPA-registered chemical aquatic herbicides and integrated management with weevil stocking in protected areas where their reproductive life cycle success is most probable and where the *M. spicatum* canopy is least likely to be disturbed by boat propeller action (i.e. the most highly trafficked and developed areas). If an integrated approach is assumed, care must be taken to apply herbicides many weeks prior to the weevil stocking or many weeks afterward so that residues are not detectable in nearby waters and will not have a negative impact on the weevil. None of the systemic target-specific herbicides proposed to be used in this program bioaccumulate in lake sediments or are toxic to aquatic life if used according to label dose rates and are applied by a licensed herbicide applicator with proper oversight. A whole-lake aquatic herbicide treatment is not recommended since approximately 42.9% of the sampling location grid points did not contain vegetation a lake-wide treatment would be wasteful in areas that are barren and could potentially alter the native aquatic plant communities. Thus, a combination of spot-treatments with systemic herbicides and biological control (in different areas of the lake) is strongly encouraged.

Figure 1. Aerial photo of Paradise Lake, Emmet and Cheboygan Counties, Michigan (MIRIS, 2006 aerial photo database).

2.0 AQUATIC PLANT SURVEY METHODS

The aquatic plant sampling methods used for lake surveys of macrophyte communities commonly consist of shoreline surveys, visual abundance surveys, transect surveys, Aquatic Vegetation Assessment Site (AVAS) Surveys, and GPS Point-Intercept Grid surveys. Other less common and more costly surveys that involve bioacoustic monitoring and/or side-scan sonar imaging are used to determine biomass density in very large bodies of water (i.e. Chesapeake Bay, US). The Michigan Department of Environmental Quality (MDEQ) protocol consists of an Aquatic Vegetation Assessment Site (AVAS) Survey which assigns a percentage of cover to each sampled quadrat based on visual estimates (Table 1), whereas the U.S. Army Corps of Engineers utilizes a GPS Point-Intercept Grid survey for inland lakes following large-scale lake improvement treatments to assess the changes in aquatic vegetation structure and to record the relative abundance and locations of native aquatic plant species. Due to the shallow mean depth and large size of Paradise Lake, a bi-seasonal GPS Point-Intercept Grid survey is preferred to assess all aquatic species.

MDEQ Species Abundance Code	***Abundance Meaning Interpretation***	***% Coverage of AVAS Surface Area***
a	**Found**	**< 2**
b	**Sparse**	**2 - 20**
c	**Common**	**21 – 60**
d	**Dense**	**> 60**

Table 1. MDEQ AVAS species relative abundance codes used in AVAS surveys.

2.1 The GPS Point-Intercept Grid Survey Method

While the MDEQ AVAS protocol considers sampling vegetation using visual observations in areas around the littoral zone, the Point-Intercept Grid Survey method (Appendix A) is meant to assess vegetation throughout the entire surface area of a lake (Madsen et al. 1994; 1996). This method involves conducting measurements at Global Positioning Systems (GPS)-defined locations that have been pre-selected on the computer to avoid sampling bias. Furthermore, the GPS points are equally spaced on a map. The points should be placed together as closely and feasibly as possible to obtain adequate information of the aquatic vegetation communities throughout the entire lake. At each GPS grid point location, two rake tosses are conducted and the aquatic vegetation species and abundance are recorded. In between the GPS points, any additional species and their relative abundance are also recorded using visual techniques. This is especially important to add to the GPS Point-Intercept method, since *M. spicatum* and other invasive plants may be present between GPS points but not necessarily at the pre-selected GPS points. Once the aquatic vegetation communities throughout the lake have been recorded using the GPS points, the data can be placed into a Geographic Information System (GIS) software package to create maps showing the distribution of a particular species. The GPS Point-Intercept method is particularly useful for monitoring aquatic vegetation communities through time and for identification of nuisance species that could potentially spread to other previously uninhabited areas of the lake. For this particular survey, a total of 609 GPS grid points were sampled throughout Paradise Lake. This number of grid points was selected to dramatically increase the sample size necessary to reduce variability among lake sampling sites and to yield an accurate estimate of *M. spicatum* acreage.

3.0 PARADISE LAKE AQUATIC VEGETATION COMMUNITIES

Aquatic vegetation communities assessed within and around Paradise Lake during the GPS Point-Intercept survey included rooted submersed, non-rooted submersed, floating-leaved, and emergent aquatic macrophyte species. One exotic species (Eurasian Watermilfoil, *M. spicatum*) was found in Paradise Lake during this survey.

3.1 Paradise Lake Exotic Aquatic Plant Species

Eurasian Watermilfoil (*M. spicatum*; Figure 2) is a non-native (i.e. exotic), invasive, submersed, perennial aquatic plant which was introduced into the United States in the 1880's (Reed 1997), although other reports (Couch and Nelson 1985) suggest it was discovered in the 1940's. Exotic aquatic plants are not native to a particular site, but are introduced by some biotic (living) or abiotic (non-living) vector. Such vectors include the transfer of aquatic plant seeds and fragments by boats and trailers (especially if the lake has public access sites), waterfowl, or by wind dispersal. In addition, exotic species may be introduced into aquatic systems through the release of aquarium or water garden plants into a water body. An aquatic exotic species may have profound impacts on the aquatic ecosystem. *M. spicatum* has since spread to thousands of inland lakes in various states through the use of boats and trailers, waterfowl, seed dispersal, and intentional introduction for fish habitat. *M. spicatum* is a major threat to the ecological balance of an aquatic ecosystem through causation of significant declines in favorable native vegetation within lakes (Madsen et al. 1991), and may limit light from reaching native aquatic plant species (Newroth 1985; Aiken et al. 1979). The aquatic plant frequently forms dense surface canopies on inland lakes (Figure 3). Additionally, *M. spicatum* can alter the macroinvertebrate populations associated with particular native plants of certain structural architecture (Newroth 1985). *M. spicatum* beds have been associated with less macroinvertebrate biodiversity than native aquatic vegetation beds (Soszka 1975; Keast 1984; Cattaneo et *al*. 1998). The canopy created by *M. spicatum* creates an unfavorable environment for aquatic biota through the creation of stagnant water conditions which lead to increased water temperatures and lower dissolved oxygen concentrations (Unmuth et *al.* 2000; Figure 4). Cheruvelil et *al*. (2001) studied the macroinvertebrate communities on *M. spicatum* in six southern Michigan lakes and discovered that the amount of macroinvertebrates on the most dominant plant species declines as *M. spicatum* biomass increases. Since the introduction of *M. spicatum*, many nuisance aquatic plant management techniques such as chemical herbicides, biological control, and in extreme cases, mechanical harvesting, have been implemented.

Figure 2. Eurasian Watermilfoil with seed head and lateral branches.

Figure 3. Eurasian Watermilfoil canopy on Paradise Lake (July, 2009).

Figure 4. Eurasian Watermilfoil canopy with filamentous algae and stagnant water conditions on Paradise Lake (July, 2009).

The GPS Point-Intercept survey of 609 sampling points revealed that approximately 497 acres of Paradise Lake was currently infested with *M. spicatum* (Appendix B). It was located in 41.0% of the GPS sampling locations, with 22% of those at the “a” density level, 17% at the “b” density level, 16% at the “c” density level, and 45% at the “d” or most dense level. There were five distinct beds located throughout the lake that varied in size from 19 acres to 180 acres. The smallest beds were located in the central (19 acres) and southern (39 acres) portions of the lake. The majority of the *M. spicatum* plants in these two beds are sparse in abundance. An intermediate-sized bed (102 acres) located at the west side of the lake contained primarily dense *M. spicatum*. Finally, the two largest beds which were located at the northwest side (180 acres) and east side (157 acres) of the lake contained common to dense quantities of *M. spicatum.* The biodiversity of native aquatic plant species is strongly threatened in areas where the *M. spicatum* is common to dense, and since the plant propagates by fragmentation, many areas that are currently sparse in density may become more infested, especially in areas not well-vegetated with native aquatic plant species.

3.2 Paradise Lake Native Aquatic Plant Species

During the survey, a total of 13 submersed, 1 floating-leaved, and 1 emergent native aquatic plant species were found. The most dominant native aquatic plant species within Paradise Lake were in the Potamogetonaceae family, which included the Pondweeds such as White-stem Pondweed (*Potamogeton praelongus*), and Fern-leaf Pondweed (*P. robbinsii*). *P. praelongus* was present in 38.9% of the grid points sampled and thus was the most dominant rooted native submersed aquatic plant in the littoral zone. *P. robbinsii* was the second most abundant species which was present in 25.9% of the sampling locations. *P. robbinsii* often carpeted the lake bottom and formed a thick layer which makes it difficult for newly formed *M. spicatum* fragments to take root in the lake bottom sediment. Thus, preservation of this and other low-growing species is critical for the long-term control of *M. spicatum* and other nuisance species which spread through fragmentation. Another fairly abundant pondweed which occupied 17.9% of the sampling locations was *P. richardsonii*, which resembles a smaller version of *P. praelongus*. The pondweeds serve as excellent cover for fish and macroinvertebrates and should be preserved to the extent possible to support a healthy fishery. The most abundant aquatic plant which is not in the pondweed family and was present in 18.2% of the sampling locations was *Elodea canadensis*. *E. canadensis* overwinters and has small, green, rounded leaves which grow in whorls of three and is often found in sediments with high organic matter content. The submersed aquatic macrophyte *Najas flexilis* (Slender Naiad), which occupied 12.8% of the sampling locations, is a key aquatic plant for many species of waterfowl and small mammals. The majority of the native aquatic plant species in Paradise Lake were sparse to common in abundance and do not currently impart a threat to the balance of the ecosystem or to the safety of recreationalists on the lake.

Aquatic Macrophyte Species	***Aquatic Macrophyte Common Name***	***Aquatic Macrophyte Growth Form***	***% of Quadrats Present (of 609)***
Myriophyllum spicatum,1	Eurasian Watermilfoil	Submersed	41.0
Chara vulgaris (macroalga),3	Muskgrass	Submersed	5.4
Potamogeton pectinatus,4	Thin-leaf Pondweed	Submersed	4.1
Potamogeton zosteriformis,5	Flat-stem Pondweed	Submersed	3.8
Potamogeton robbinsii,6	Fern-leaf Pondweed	Submersed	25.9
Potamogeton gramineus,7	Variable-leaf Pondweed	Submersed	0.16
Potamogeton praelongus,8	White-stem Pondweed	Submersed	38.9
Potamogeton richardsonii,9	Clasping-leaf Pondweed	Submersed	17.9
Potamogeton amplifolius,11	Large-leaf Pondweed	Submersed	2.79
Vallisneria americana,15	Wild Celery	Submersed	1.15
Ceratophyllum demersum,20	Coontail	Submersed	0.5
Elodea canadensis,21	Common Waterweed	Submersed	18.2
Utricularia vulgaris, 23	Common Bladderwort	Submersed	2.8
Najas flexilis,26	Slender Naiad	Submersed	12.8
Nuphar sp.,31	Yellow Waterlily	Floating-Leaved	2.6
Typha sp.,39	Bulrushes	Emergent	4.8

Table 2. Frequency table of aquatic vegetation species in Paradise Lake (July, 2009).

Note: Based on GPS Point-Intercept grid survey of 609 sampling locations on Paradise Lake.

4.0 PARADISE LAKE EWM CONTROL OPTIONS

4.1 Biological Control with Weevils

The use of the aquatic weevil, *Euhrychiopsis lecontei* to control *M. spicatum* has become a popular option for many inland lakes. The weevil naturally exists in many of our lakes; however, the lack of adequate populations in many lakes requires that they be implanted or stocked for successful control of *M. spicatum*. The weevil feeds almost entirely on *M. spicatum* and will leave native aquatic species unharmed if adequate amounts of *M. spicatum* are present. The weevil burrows into the stems of *M. spicatum* and damages the vascular tissue, thereby reducing the plant's ability to store carbohydrates (Newman et al. 1996). Eventually, the *M. spicatum* stems lose buoyancy and the plant decomposes on the lake bottom.

Recent research has shown that the weevils require a substantial amount of aquatic plant biomass for successful control of *M. spicatum*. In addition, the weevils require adequate over-wintering habitat since they overwinter within shoreline vegetation. Lakes with sparse *M. spicatum* distribution are not ideal candidates for the milfoil weevil. Recent peer-reviewed scientific research by Newman and Biesboer (2000) and a recent study conducted by Lakeshore Environmental, Inc. on Round Lake (Lenawee County, MI) in 2008 demonstrates that the requirements for weevil stocking density to obtain adequate control of *M. spicatum* may be as high as 150-300 weevils per square meter.

On July 10, 2009, a limnologist from Lakeshore Environmental, Inc. accompanied members from Friends of Paradise Lake (FoPL) on a Paradise Lake tour and confirmed that the weevils were trying to feed on the *M. spicatum*, but in many locations were unable to keep up with the excessive amount of biomass. A map recently obtained from the Paradise Lake Association (PLA) and prepared by the Tipp of the Mitt Watershed Council showed the previous weevil stocking areas to be at the west-central, north, and northeast portions of the lake. All of these areas currently contain common to dense quantities of *M. spicatum* and thus further stockings are recommended. Weevils should only be considered in areas where boat traffic is minimized to reduce the propagation of milfoil fragments (thus reducing further spread of the plant) and to maximize the survivorship of the weevil generations.

4.2 Spot-treatments with Systemic Aquatic Herbicides

The use of aquatic chemical herbicides is regulated by the MDEQ under Part 33 (Aquatic Nuisance) of the Natural Resources and Environmental Protection Act, P.A. 451 of 1994, and requires a permit from the Michigan Department of Environmental Quality (MDEQ). The permit contains a list of approved herbicides for a particular body of water, as well as dosage rates, treatment areas, and water use restrictions. Furthermore, residents that reside within 100 feet of the proposed treatment area must be notified at least seven days, but not more than forty-five days prior to the initial treatment date. A certified herbicide applicator usually notices the residents in advance of the proposed treatment date, and during the day of treatment. Contact and systemic aquatic herbicides are the two primary herbicide types used in aquatic systems. Contact herbicides cause damage to leaf and stem structures; whereas systemic herbicides are assimilated by the plant roots and are lethal to the entire plant. Wherever possible, it is preferred to use a systemic herbicide for longer-lasting aquatic plant control. There are often restrictions with usage of some systemic herbicides around shoreline areas that contain shallow drinking wells. Systemic herbicides such as 2,4-D and Triclopyr (Trade Name: Renovate) could be used to successfully treat localized or widely dispersed beds of *M. spicatum*. The current infestation of Paradise Lake could be spot-treated with systemic herbicides such as 2,4-D if offshore or Triclopyr if near shore for selective long-term control, with little negative impacts to the native aquatic vegetation communities within the lake. Triclopyr should be used with an adjuvant to increase its ability to adhere to the aquatic plants. In addition, all herbicides should be applied during calm weather conditions to minimize drift of the chemical from the treatment site.

This approach was recently highly successful in both Lake Mitchell (Wexford County, MI) and Bear Lake (Manistee County, MI). Approximately 365 acres of *M. spicatum* were spot-treated with the systemic aquatic herbicides 2,4-D and Triclopyr in Lake Mitchell during early June of 2009, which is a 2,580 acre lake that contained *M. spicatum* in various areas throughout its basin. GPS technology was used to guide the herbicide applicator to areas infested with *M. spicatum* following a 990-point GPS grid survey to assure that application would only be administered to those areas infested with the exotic species. At present, only a small amount of *M. spicatum* remains, which is being consumed by weevils in the Big Cove area as a part of the Integrated Management Plan. As an additional case study, approximately 320 acres of *M. spicatum* was treated with 2,4-D and Triclopyr in Bear Lake during mid-summer of 2008, and only 11 acres was necessary to be treated in July of 2009.

4.3 Whole-lake Fluridone Aquatic Herbicide Treatments

Fluridone (trade name, SONAR®) is a systemic whole-lake herbicide treatment that is applied to the entire lake volume in the spring. The objective of a fluridone treatment is to selectively control the growth of *M. spicatum* in order to allow other native aquatic plants to germinate and create a more diverse aquatic plant community. A whole-lake treatment of fluridone could be an affordable option for the control of *M. spicatum* within Paradise Lake if spot-treatments are not able to effectively control the current infestation, or if the options presented below are not affordable to the public. However, due to the fact that 42.9% of the sampling locations contained no aquatic vegetation, a fluridone treatment would not be recommended at this time, as it would likely lead to a reduction of too many aquatic plants which could have significant detrimental impacts on the lake fishery and entire aquatic ecosystem.

4.4 Integrated Management

Integrated management involves the use of a combination of management methods which may include chemical, biological, mechanical, aeration, or other techniques for aquatic plant control. Integrated management is becoming increasingly common since aquatic ecosystems are multi-dimensional and have different vegetation communities in certain lake areas and thus may show variable responses to specific treatments. The recommended use of both systemic chemical herbicides and weevils for the *M. spicatum* present within Paradise Lake is indicative of an integrated management plan. If weevils are used in combination with herbicides, care must be taken to assure that the weevils are stocked during a period when chemical herbicide residues may not be detected in the water column and have been completely assimilated by treated *M. spicatum* plants. Table 3 below displays an integrated aquatic plant management annual budget option for the control of *M. spicatum* in Paradise Lake.

Proposed Paradise Lake Improvement Item	***Estimated 2010 Cost***
Biological Control (weevils): Recommended stocking in 157-acre EWM bed (NE corner)-40,000 units @ $1.20 per unit Stocking/Evaluation Fees: $3,000	$51,000
Aquatic Herbicides-(2,4-D for 340 acres@$345/acre) MDEQ permit fee: $1,500	$118,800
Limnologist/Oversight/Surveys/Reports/Newsletters/WQ Monitoring/Expert Guidance	$8,000
Contingency (est. 10% of total project cost)	$17,780
TOTAL 2010 ESTIMATED COST	$195,580

Table 3. Estimated annual cost of an Integrated Management Plan for Paradise Lake.
Note: Costs should only be for biological control and/or small-scale aquatic herbicide treatments and oversight for 2011 and beyond.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The urgent control of the 497 acres of *M. spicatum* throughout Paradise Lake is essential for the long-term preservation of the native aquatic plant communities. Furthermore, the selected methods for the control of *M. spicatum* should also protect native aquatic plant species through targeted control. Paradise Lake possesses a strong fishery, with many species of native aquatic plants that help to support the associated fishery through housing macroinvertebrates (fish food) and providing habitat and shelter in a large, yet shallow open-water system. The preferred aquatic plant management method(s) must also satisfy the needs of lake residents, by enhancing recreational activities such as boating (navigation) and fishing, increasing the safety of swimming, and protecting the property values of surrounding homes. Thus, management options retain socio-economic characteristics that influence both riparians and individual components of the Paradise Lake ecosystem. In the past few years, available aquatic plant management techniques have been discussed for the *M. spicatum* problem within Paradise Lake; however, based on the socio-economic climate and urgency of this problem, an integrated approach is strongly recommended to both complement the philosophical needs of those opposed to aquatic herbicides and also those who favor the use of a more rapid approach to the control of *M. spicatum*, which currently occupies 41% of the sampling locations. It is therefore recommended that the two small *M. spicatum* beds be treated with systemic aquatic herbicides since they contain sparse quantities of milfoil that would respond best to spot-treatment and this would be the most cost-effective approach for a bed of this size. The two large *M. spicatum* beds located at the north and west portions of the lake contain dense milfoil but are in areas which receive high boat traffic. Additionally, these areas contain thick milfoil canopies which must be treated aggressively to stop the propagation and fragmentation of milfoil which is spreading the plant to other areas of the lake. Thus, it is recommended that these two beds be treated with a systemic aquatic herbicide as well. The large 157-acre bed at the far east side of the lake would be the most ideal location to place weevils for a successful component of an Integrated Management Plan. A stocking amount of 40,000 weevils in the 157-acre bed is recommended to facilitate a strong weevil population early in the spring season. If this is successful, then it possible that long-term dependence on aquatic herbicides may be diminished and the weevil population may flourish throughout the lake and gain control over an acreage of *M. spicatum* that it can finally manage without the production of *M. spicatum* canopies as is currently occurring throughout many areas of the lake.

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APPENDIX A

GPS POINT-INTERCEPT METHOD FOR AQUATIC VEGETATION SURVEYS

APPENDIX B

MAP OF PARADISE LAKE EURASIAN WATERMILFOIL BEDS (JULY, 2009)

APPENDIX C

PARADISE LAKE AQUATIC VEGETATION DATA BY GPS LOCATION (JULY, 2009)

GPS Sample Quadrat	*Macrophyte Species and Abundance Present*
711	1d,5a,6a
712	1d,5a,6a,7a
713	None
714	None
715	1a,31a,21a
716	None
717	1d,11a,9a
718	None
719	11a,9a
720	None
721	31c,39c
722	1b
723	1d,11a,8a,9a,6b
724	1d,11a,9a,6c,26c
725	1d,21a,5a,23a
726	1d,11a,8a,21a,9a,26c
727	1d,11b,8a,21a,9a,6c
728	1c,21a,11a,9a,26c
729	1c,11a,21a,9a
730	1d,11a,21a,9a,6b
731	1d,11a,8a,21a,9a,6b
732	1d,11a,9a,6b,26b
733	1d,11a,9a,6b
734	1d,9a,11a,6c,26c
735	1c,9a,11a,6b

GPS Sample Quadrat	***Macrophyte Species and Abundance Present***
736	1d,9a,8a,21b,23a,6b
737	1d,9a,8a,21a,6b
738	1d,8a,21a,6b
739	1c,21a,15a,6b,26b
740	None
741	31b
742	31a
743	None
744	1d,8a,6a,26b
745	1d,23a,8a,21a,5a,6b
746	1d
747	1d,8b,6b
748	1d,8b
749	1d,8a,6a
750	1d,8a,6a,26b
751	1d,8b,5a,6b
752	1c,5b,8a,6c,26b
753	1d,8a,6c,26b
754	1c,8a,5a,21a,6c,26b
755	1b,8a,5a,26c,6c
756	1d,8a,6c,26b
757	1d,8a6b,26b
758	1d,8a,21a,6b,26b
759	1d,8a,6b
760	None
761	1c,8a,11a,21a,6b
762	1d,8a,11a,21a,6b

GPS Sample Quadrat	*Macrophyte Species and Abundance Present*
763	1d,8a,11a,21a,6b
764	21a,4a
765	1d,8a,9a,6b,26b
766	1b,8a,9a,6b,26b
767	None
768	39b (shore)
769	39c (shore)
770	1d,8a,21a,6b
771	1d,8a,21a,9a,6b
772	1d,8a,6a
773	4a
774	1d,8a,6a,26b
775	1c,8a,6a,26c
776	1b,8b,6b,26c
777	1d,8a,9b,6a
778	3a,15a
779	1d,8a,9a,6b
780	1c,8a,6c
781	1b,8b,6b
782	1d,6c,26c
783	1d,8a,6d,26b
784	1c,8a,6b,26b
785	1d,8a,9a,6b,26c
786	1c,8a,9a,6b,26c
787	1a,8a,6c,26b
788	1a,21a,15a

GPS Sample Quadrat	*Macrophyte Species and Abundance Present*
789	1d,21a,8a,6b
790	3a
791	1d,9a,6b
792	1d,8a,6a
793	21b,8a
794	1c
795	39d (shore)
796	8a,9a,21a
797	1d,8a,21a,6b
798	1d,8a,21a,6b
799	1d,8a,9a,21a,6b
800	None
801	1d,6a
802	1a,9c
803	1b,9a,8a,6b
804	9a,8b,1a
805	1a,8a,6b
806	8a,1c
807	1d,8a
808	1c,8a,5a
809	1d
810	1d,8a,9a,6b
811	1c,8a,9a,6c
812	1d,5a,8a,9a,21a,20a,6c
813	1b,8a,9a,21a,6b
814	8a,9a,21a

GPS Sample Quadrat	*Macrophyte Species and Abundance Present*
815	1d,8a,9b,21a,6b
816	4a
817	None
818	None
819	1d
820	1d,8a,9b,21a,6b,26b
821	1d,8a,9b,21a,26a
822	1d,8a,5a,21a,26b,6b
823	1a,5a
824	None
825	39a (shore)
826	39a (shore)
827	None
828	1d,8a,9a,21a,26c,6c
829	1c,8a,9b,21a,6b
830	1d
831	1a,9c,8a,6c
832	1a,9c,8a,26b
833	1d
834	1b,21a,4a,26b
835	None
836	None
837	1d,8a,9a,21a
838	8a,9a
839	None
840	None

GPS Sample Quadrat	***Macrophyte Species and Abundance Present***
841	21a
842	1d,9b,6b
843	None
844	None
845	4a
846	1d,8a,9a
847	1d
848	1d
849	1c
850	1c,21a,4a,15a,26b,6b
851	None
852	39a (shore)
853	None
854	None
855	1c,8a,9a,21a,6b,26c
856	1a,8a,23a,6c,26a
857	1a,8a,9a,21a
858	1d,8a,9a
859	1c,8a,9a,20a,21a
860	None
861	None
862	None
863	1d,9b,8a,6a
864	1c,9a,8a
865	None
866	None

GPS Sample Quadrat	***Macrophyte Species and Abundance Present***
867	None
868	None
869	1d,8a
870	1d,8a,9a,6b
871	1d,8a,9a,6b,26a
872	23a
873	None
874	15a,23a,8a
875	8a
876	3a,8a,23a,15a
877	3a,8a
878	1a,3a,8a
879	1a,8a,3a,6a
880	1a,8a,23a
881	1a,3a,8a
882	None
883	None
884	None
885	39a (shore)
886	None
887	None
888	None
889	None
890	None
891	None
892	None

GPS Sample Quadrat	***Macrophyte Species and Abundance Present***
893	1a
894	1d,3b,8a
895	1c,8a
896	1c,8a,9a,23a
897	1b,8a
898	8a,9a,23a
899	8d,9a,23a
900	3a,9a,8a
901	None
902	None
903	1d,8a,21a
904	1d,8a,21a
905	1a,8a,3a
906	1a,8a,23a
907	1a,3a,8a
908	None
909	1d
910	1d,8a,9a,21a
911	1a,8a,9a
912	None
913	None
914	None
915	3a
916	3a
917	3a
918	None

GPS Sample Quadrat	*Macrophyte Species and Abundance Present*
919	None
920	None
921	None
922	None
923	None
924	None
925	None
926	None
927	3a
928	3a
929	3a,8a
930	None
931	None
932	None
933	1a,8a
934	1a,8a,6b,26a
935	1a,8a
936	8a
937	None
938	None
939	None
940	None
941	None
942	None
943	None
944	None

GPS Sample Quadrat	***Macrophyte Species and Abundance Present***
945	None
946	1a,8a,9a,6a,26b
947	1a,8b
948	None
949	3b,1b
950	1c,8b,21b,6c,26b
951	1d,8b,21a,6b,26c
952	1c,8b,39a,6b,26b
953	None
954	1d,8a,6b
955	1b,8b,6c
956	None
957	None
958	8b
959	1b,8b,3b
960	None
961	None
962	None
963	None
964	None
965	None
966	1b,8b,6c
967	1b,8b,6b
968	1a,8a,4b,6b
969	1b,8b,4a,6c
970	1a,8a,21a,4b,6b

GPS Sample Quadrat	***Macrophyte Species and Abundance Present***
971	1b,8a,6b,26a
972	1d,8a,6a,26b
973	None
974	None
975	1c,8a
976	None
977	None
978	None
979	8a
980	None
981	None
982	None
983	None
984	None
985	None
986	None
987	None
988	None
989	8b
990	1c,8a,6a
991	1b,8a
992	1b,8a
993	None
994	None
995	1d
996	1d

GPS Sample Quadrat	***Macrophyte Species and Abundance Present***
997	None
998	39b
999	39b
1000	None
1001	None
1002	None
1003	None
1004	None
1005	None
1006	None
1007	None
1008	None
1009	None
1010	None
1011	None
1012	None
1013	None
1014	None
1015	None
1016	None
1017	None
1018	None
1019	1d,8a,21a,6c,26b
1020	1d,8a,21a,6b,26b
1021	1b,8a,39a,6b,26c
1022	39a

GPS Sample Quadrat	*Macrophyte Species and Abundance Present*
1023	1d,8a,9a,6a
1024	1d
1025	None
1026	None
1027	None
1028	1a,8a
1029	None
1030	None
1031	None
1032	None
1033	None
1034	None
1035	None
1036	None
1037	None
1038	None
1039	None
1040	None
1041	1a
1042	1a,3a,8a,23a,6b,26b
1043	None
1044	None
1045	None
1046	39a
1047	39a
1048	None

GPS Sample Quadrat	*Macrophyte Species and Abundance Present*
1049	None
1050	3a,8a,4a
1051	3a,4a
1052	3a,4a,8a
1053	None
1054	None
1055	None
1056	None
1057	4a,8a
1058	None
1059	None
1060	None
1061	None
1062	None
1063	8a,9a,4a,6a
1064	None
1065	None
1066	None
1067	1d,8a,21a,9a,6b,26b
1068	1d,8a,21a,9a,6c,26b
1069	None
1070	None
1071	None
1072	1d,8a,21a,9a,6b,26b
1073	1d,8a,9a,21a,6b,26b
1074	1c,8a,9a,6b,26b

GPS Sample Quadrat	*Macrophyte Species and Abundance Present*
1075	None
1076	None
1077	None
1078	1a,8a,4a
1079	None
1080	None
1081	None
1082	None
1083	None
1084	None
1085	None
1086	None
1087	None
1088	None
1089	None
1090	3a,8a
1091	None
1092	None
1093	None
1094	None
1095	39a
1096	39a
1097	None
1098	None
1099	None
1100	None

GPS Sample Quadrat	***Macrophyte Species and Abundance Present***
1101	None
1102	3a,4a
1103	None
1104	None
1105	None
1106	39a
1107	39a
1108	None
1109	None
1110	None
1112	None
1113	None
1114	None
1115	39a
1116	39b
1117	None
1118	None
1119	None
1120	None
1121	None
1122	None
1123	None
1124	None
1125	None
1126	39a
1127	None

GPS Sample Quadrat	*Macrophyte Species and Abundance Present*
1128	None
1129	39a
1130	None
1131	None
1132	None
1133	None
1134	None
1135	None
1136	39b (near shore)
1137	39b (near shore)
1138	39b (off shore)
1139	None
1140	None
1141	1a,8a,4a
1142	1a,8a
1143	1a,8a
1144	1a,8a
1145	1a,8a
1146	None
1147	None
1148	1d,8a
1149	1d,5d,8a,9a,6b,26a
1150	1d,5b,8a,9a,6a,26a
1151	None
1152	None
1153	None

GPS Sample Quadrat	*Macrophyte Species and Abundance Present*
1154	None
1155	1d,8a,9b,5b,6b,26c
1156	1d,5b,9a,8a,6c
1157	8a
1158	8a
1159	8a
1160	8a,21a,6a,26a
1161	8a,21a
1162	1a,21a,8a
1163	None
1164	None
1165	None
1166	None
1167	None
1168	8a,21a
1169	8a
1170	None
1171	None
1172	None
1173	1a,21a
1174	1a,21a
1175	1c,21b,8a,6b,26b
1176	1d,5b,21a,8a,9a,6b,26b
1177	1d,5b,21a,8a,9a,6b,26c
1178	1d,5a,21a,8a,9a,6c,26b
1179	39c

GPS Sample Quadrat	*Macrophyte Species and Abundance Present*
1180	None
1181	None
1182	1d,8a,9a,6a
1183	1d,21a,8a,9a,6a,26b
1184	1d,21a,8a,9a,5a,6b,26b
1185	1a,4a
1186	1a,4a
1187	None
1188	None
1189	None
1190	1a
1191	None
1192	39a (offshore)
1193	39a (nearshore)
1194	None
1195	1b,8a
1196	None
1197	None
1198	None
1199	None
1200	None
1201	1c,8a,9a,21a,6a,26a
1202	1d
1203	1d,4a,8a,9a,21a,5a,6b
1204	1d,8a,9a
1205	1b,8a

GPS Sample Quadrat	***Macrophyte Species and Abundance Present***
1206	1b,8a,6a
1207	1c,8a,9a,6b,26a
1208	1b,8a,6a,26a
1209	1b,8a,6b
1210	1d,8a,9a,21a,6a
1211	1d,8a,9a,6c
1212	1d,8a,9a,6b
1213	1b,8a,9a,6b
1214	None
1215	4a
1216	1a,8a,4a
1217	1a,8a,4a
1218	None
1219	1b,8a,9a,21a,6b,26c
1220	1c,8a,9a,21a,6b,26b
1221	None
1222	None
1223	1d,8a,21a,6c,26b
1224	1b,8a,21a,9a
1225	1b,8a,9a,21a,6c,26c
1226	1b,8a,21a,6b,26b
1227	1c,8b,23b,21b,6b
1228	1b,8a,21a,6b,26b
1229	1a,21b,23b,6b
1230	1a,21b,23a,6b
1231	1a,21a

GPS Sample Quadrat	*Macrophyte Species and Abundance Present*
1232	1d,21b,8a,9a,6a
1233	1d,8a,9a,21a,6b,26a
1234	1d,8a,9a,21a,6a
1235	1c,8a,9a,21a,6a
1236	1c,8a,9a,21a,6b
1237	1a,8a,9a,15a,21a
1238	1b,8a,9a,6b
1239	1c,8a,9a,6b
1240	1d,5b,8a,9a,39c,6b,26b
1241	1c,5b,8a,9a
1242	1b,8a,9b,6b,26b
1243	1d,9b,8b
1244	1a,21a,8a
1245	8b,1b,21a,6b
1246	None
1247	21a,4a
1248	1a,8a,9a,21a,6b
1249	1b,8a,21a,23a
1250	1d,8a,21a,6a
1251	1b,8a,21a,9a,21a,6b
1252	1b,8a,21a,6b,26b
1253	1a,8a,21a,6b,26a
1254	1a,8a,21a
1255	None
1256	None
1257	1a,8a,21a

GPS Sample Quadrat	*Macrophyte Species and Abundance Present*
1258	1b,8a,21a,6b,26a
1259	1b,8b,21a,6a
1260	8b,4a,6b
1261	8a,4a,6b,26a
1262	1d,8a,9a,21a,6c
1263	1c,8a,9a,21a,6c
1264	1b,8a,9a,21a,6b
1265	1b,9a,8a,21a,6b,26b
1266	1c,8a,21a
1267	1a,8a,21a
1268	1b,8b,21a,6b
1269	1b,4a,8a,21a
1270	None
1271	1b,9c,8b
1272	1c,8a,21b,6b
1273	1b,8a,9a,21a
1274	1b,8a,9a,21a
1275	8a,3a,23a
1276	3a,8a,23a
1277	3a
1278	3a,8a
1279	3a,8a
1280	3a,8a
1281	None
1282	3a,8a
1283	3a

GPS Sample Quadrat	***Macrophyte Species and Abundance Present***
1284	3a
1285	None
1286	None
1287	39a (nearshore)
1288	None
1289	None
1290	None
1300	None
1301	None
1302	None
1303	None
1304	None
1305	None
1306	None
1307	None
1308	None
1309	None
1310	None
1311	None
1312	None
1313	None
1314	None
1315	None
1316	None
1317	None
1318	None

GPS Sample Quadrat	***Macrophyte Species and Abundance Present***
1319	None
1320	None