(Feb. 25, 2014)

Eurasian Water-milfoil Survey Of Kangaroo Lake For Years 2006, 2008 and 2010. Plant Density, Plant Distribution, Water Depth, Bottom Character.

Paul Mahlberg*, Robert Schoof and Marilyn Mahlberg
(pmmahlberg@Yahoo.com) Baileys Harbor, WI 54202
*Chairman, Lake Study Committee

Summary. These surveys are an outgrowth of our Kangaroo Lake Comprehensive Lake Management Study completed in 2004. Studies showed Eurasian Water-Milfoil (EWM) to be present and abundant in several locations in the middle area of the lake. Populations of EWM now occupy regions formerly occupied by native plants such as pondweeds (Potamogeton), as documented in past aerial photographs and recollections of older lake residents. Other parameters, including lake depth, accompanying plant species as well as lake bottom character, were included in the study to aid the interpretation of EWM on the biology of Kangaroo Lake. The surveys showed EWM to be spreading throughout the lake. Our interest is to determine the bases for its expansion and to develop ways and procedures to minimize its possible negative impact on the biology of Kangaroo Lake.

Introduction. This study was initiated following the completion (NES, 2004) of our Comprehensive Lake Management Study of Kangaroo Lake (Figure 1). Several members of our Association, with the encouragement from Tim Hoyman, who carried out the lake management study on behalf of NES, proposed that we study the impact of EWM in the lake. A first step in considering management of EWM necessitates the determination of its distribution and abundance throughout the lake over a multiple period of years. Thus, we initiated in 2006 a biennial survey of EWM distribution using the point intercept procedure to examine Kangaroo Lake for the distribution of EWM (Figure 2).

This report documents the current locations and the effect of time on distribution of EWM, and associated features, using the point intercept coordinate grid on the large lake lobe south of the causeway. Results from this study make it possible to plan some kind of action on EWM as well as to compare its present distribution with that in future years so as to follow its rate and extent of spread in the lake.

An added parameter to this study of EWM distribution was the placement of 31 large log fish cribs in the lake (2002-03), and how they would impact EWM distribution (Figure 3). Cribs were not placed directly on any of the point intercept coordinates. Also they were empty of any plants at the time of placement. It was assumed, however, that plants either native or EWM may be growing in the vicinity of these empty cribs. Thus, if aquatic plants were to develop inside the cribs in subsequent years they would represent new locations.

The first survey, in 2006, was followed by similar surveys in 2008 and 2010 to gain insight on the progression of its spread during a period of time. We then prepared enlarged maps of the lake that contain color symbols to show distribution of EWM as determined from the surveys (Figures 4, 5, 6). Thus, we now have data from three surveys, 2006, 2008 and 2010 for comparative study [Table 1 (2006); Table 2 (2008); Table 3 (2010)].

Procedures. Kangaroo Lake is a large, shallow body of water divided by a causeway road into a small undeveloped northern lobe, ~200 acres, and a large developed southern lobe, ~1000 acres, in which this study was done (Figure 1). It is an elongated lake 3 miles long and about 1-mile wide, with an average depth of 6 feet and a maximum depth of 12 feet in a small area. This shallow lake is within 2 miles of Lake Michigan which affects its weather in that it becomes very rough from high winds associated with Lake Michigan.

The lake is fed by a small stream, Piel Creek, at its extreme north end. Heins Creek at the southeastern end drains the lake over a fixed dam and then descends 20 feet to Lake Michigan. Area of lake under 3 feet is 23%. It has a shoreline length of 9.35 miles, much of which in the south lobe has been cleared of fallen trees, although there are small undeveloped areas with natural tree-falls along the shore. Water sampling studies, including the lake trophic state and water temperature, have been in progress for over 20 years and those data are available on the DNR website. Fish studies also have been carried out on a regular basis by DNR Steve Hogler and are detailed on the Kangaroo Lake website, www.kangaroolake.org.

A 15-acre island is located near the center of the lake. About 1/4 of its margin has been developed. The remaining 3/4 of its area and related shoreline are wooded with many fallen trees extending into the water. The lake bottom around the island includes zones of marl, sand, gravel and rock. The island has been classified as a sensitive area, one of six such shoreline areas designated around this portion of the lake (Gansberg and Hoymann, 2003).

Point intercept coordinates (GPS sites). For this study the lake was overlain with a grid consisting of 530 sites identified as GPS waypoints (Figure 2). Sites or GPS coordinates are separated by about 330 feet, except in the middle region of the lake where a cluster of them is spaced more closely, about 165 feet apart. This central region was sampled more intensively because it was here that EWM was first detected, and we wanted to circumscribe its distribution more closely in this region. Tim Hoyman of Onterra , LLC (2004) prepared the point intercept coordinates map. Each site was identified with a GPS instrument, Garmin Etrex, as we moved slowly along the lake to take samples at each site.

Sampling was done with a DNR-approved modified steel garden rake. It was modified by attaching a second rake-end so that rake tines extended from both sides of the rake bottom. A 15-ft handle, with a short extension, was adequate for sampling all sites. Handle length must be adequate to enable one to apply leverage to the rake tines so as to collect a sample from the lake bottom. Three people were necessary in the boat working to operate the motor, indicate GPS sites and record data, and to collect and identify plant samples on the rake. The lake was nearly at full-basin level, the water being a fraction of an inch below the top of the dam at time of sampling; this level was somewhat higher than typical for this time of year (September).

We surveyed all 530 sites in sequential order shown on the lake (Figure 2). At each site we raked a sample from the bottom to determine presence and density of EWM, and recorded it to be absent (0), only a few plants hanging on rake (1), one portion of rake covered with this plant (2), or over half of the rake covered with EWM (3). Results are given on the attached Tables 1-3 that show site number, GPS coordinates and a value of 0 to 3 for EWM density. We also collected additional data at each site, including the presence of other plant genera, lake depth in feet and character of the lake bottom. For the latter I could identify marl (very soft), sand, gravel, and rock by the feel of the rake when I moved the rake on the bottom. Data were collected in a similar manner for each report [Table 1 (2006), Table 2 (2008), Table 3 (2010)].

Fish crib installation. During the years 2002-2003 we placed 31 log cribs in Kangaroo Lake. They were constructed according to DNR guidelines and measured 8 feet long x 6 feet wide x 4 feet high boxes. A partial plank floor was placed at both ends of a crib to firm its shape. Each crib was essentially an open 8 ft. by 6 ft. box. The contractor delivered them to our two staging areas at the lakeshore.

Association members prepared them for installation. We inserted and nailed numerous hardwood branches, with 2-inch bases, to form a maze across the width at each level between the logs of a crib. This maze would provide refuge for fish when in the crib.

At this stage we tied four concrete blocks at the corners onto the plank floor to provide ballast to help sink the crib. Each crib was placed into shallow water, and we pushed them out to a depth where a crib would just float. They were left overnight to soak water and gently settle to the bottom. During this soaking period we finalized our work on a crib by attaching a concrete block to each top corner. The rope between the crib and block was about 3 feet long--long enough to enable us to place the blocks in a boat. These blocks were placed on the crib during the soaking period.

Each crib was transported to its location with small outboard motorboats. A soaked crib was positioned between the sides of two boats. The concrete blocks were temporarily placed in the boats, and the floating crib was slowly motored for 1-hour or less to a GPS-marked destination site. When at the site members in both boats simultaneously placed the four concrete blocks into the water, and the crib sank to the lake bottom in 9 ft of water. They were placed a similar distance from shore on both east and west sides of the lake (Figure 3).

Cribs were numbered 1 to 31, and placed in an oval pattern in the lake between the island and the south end, and spaced about equidistant from each other. Many cribs were named to honor those families who contributed to the cost of a crib, and a ceramic nameplate was attached to those cribs prior to placing them in the lake (Table 4).

Diving to examine cribs. Two experienced scuba divers attempted to examine and photograph the condition of the cribs during 2011. But conditions of the water, with its abundant algal content, made underwater visualization of anything around the cribs impracticable.

Results. Survey 2006. EWM was identified at 54 sites on the coordinate map (Table 5). The distribution and density among the 530 GPS sites is shown on the large colored map (Figure 4). It occurred as a mixed population with bladderwort, naiad and pondweed at densities 1 and 2, and some 3, but occurred alone at 9 of the 15 density 3 sites. Most of these sites were located in the 'middle' of the lake in the closely spaced sites shown on the map. It occurred alone at some sites where it grew as thick mats (density 3) on the lake bottom that excluded or limited growth of other plants (Table 1).

We noted that the lake bottom overall was quite barren. No plants were detected at 116 (21%) of the grid sites or lake bottom. Chara, a low-growing algal ground cover and tolerant plant, was present at 287 sites, over 50% of all sites on the lake bottom. A small-leaved pondweed, also a tolerant plant, was detected at 78 (14%) of the sites. Bladderwort and naiad each were present at 22% of the lake bottom. Large-leaf pondweed was found at only 5 (1%) of the sites; this desired plant for fish and waterfowl was formerly abundant in the lake. Only these six plants, alga, bladderwort, chara, naiad, pondweed, large-leaf pondweed along with EWM, were the common, dominant submerged plants throughout the lake, with large-leaf pondweed being negligible (Table 6).

An alga, (Dichotomosiphon tuberosus), a new report for this lake, was found on the lake bottom at 48 (9%) of the sites; it grows as a thin dark green/blackish soft mat on the bottom at depths from 4 to 11 feet. It does not occur in shallow water. Plant name was determined at a DNR laboratory (Table 6). Other algal species, not identified here, occur in the lake, both in suspension and attached on rocks and logs along the shore. These become most evident during the summer.

Survey 2008. The 2008 sampling showed EWM to be present at 37 of the 530 sites, and is shown on the enlarged colored map of the sites (Figure 5). This decreased number contrasted with the 54 sites observed in the 2006 survey. EWM presence included 15 sites with density #1, 6 sites with density #2 and 16 sites with density #3. EWM occurred alone at 14 of the 16 sites with density #3, while B or P were detected along with EWM at 4 sites. Chara was not detected at any sites containing EWM (Table 5).

Table 6 shows the name and number of aquatic plants recorded among the 530 sites. No plants (None) were detected at 152, or 28 %, of the sites. Chara (C) an alga attached to the lake bottom was most prevalent (289 sites). Bladderwort (B) was the most prevalent of seed plants at 123 sites. Naiad showed a decrease in number compared to 2006. Pondweed (P) was present at 90 sites, but large-leaf pondweed (Pl) was not detected this year. Dichotomosiphon (A), a bottom-dwelling alga, occurred at 41 sites, a level similar to that in 2006.

Survey 2010. The 2010 sampling showed EWM to be present at 36 sites of the 530 sites and is shown on the large colored map of the sampling area (Figure 6). There was a decrease in all densities for presence of EWM compared to the 2006 sampling, but the pattern in decrease was similar to that in 2008 (Table 5).

Bladderwort, naiad and large-leaf pondweed also were present at an increased number of sites compared to 2008. Large-leaf pondweed was detected at more sites in 2010 than in the previous sampling periods (Table 6).

The alga showed an increased presence over that for both 2006 and 2008. Chara increased to 68 sites (12%) on the lake bottom. Dichotomosiphon increased to 68 sites, up about 5% over 2006 and 2008. Chara grows at all water depths, but Dichotomosiphon grows only in deep water (Table 6).

Fish Cribs. It is most probable that aquatic plants were in the vicinity of cribs, although we did not search for them specifically. Placement of cribs was intended to expand the area of fish and biological habitat. Most of the lake bottom where the cribs were placed lacked submerged plants except for possibly Chara. However, within 4 years EWM was evident in the cribs. In 2010, I reconfirmed that EWM was present at all cribs. EWM has now expanded to new sites in the southern half of the lake where it was not detected previously. Similarly, fish cribs north of the central EWM presence also contained EWM (Figures 4, 5, 6; Table 5).

In several fish cribs, where the box was evident from the lake surface, EWM was the only plant and filled the entire box. Native plants were growing in the area surrounding the crib (Table 4). During late summer EWM leaves reached the lake surface as dense shoots and flowered (top out). However, all cribs did not top out each year.

Water Depth. EWM occurs predominantly in deep water--5 to12 feet deep for samples from all three years. At only a few sites was it present in shallow water of 1 to 4 feet. It does not occur typically in shallow water. Even for plants found in shallow water, they were usually a single, small-sized cluster and not robust patches. Water depth is shown at all sites (Tables 1, 2, 3).

Bottom Character. EWM populations were present primarily on marl bottom as determined from sampling sites in all three years. Only occasionally were they present on a rocky lake bottom. It was absent from lake gravel beds. But, elsewhere in the lake

--along the north side of the causeway--we have found it growing in gravel in shallow water (this area was outside of our present study). EWM was not found growing on sandy lake bottom in shallow or deep water (Tables 1, 2, 3, 7).

We do not have data for lake bottom character under the fish cribs or of the immediate area around each crib at this time.

Discussion. Eurasian Water-milfoil. Data from sampling the 530 GPS sites indicate that the abundance of EWM decreased somewhat during the three sampling periods. However, the 31 fish cribs in the lake showed a very different phenomenon in that EWM spread rapidly to all 31 fish cribs within a 5-6 year period, and was present in all cribs in 2010. As a net result the number of EWM populations in the lake has greatly increased, and are now present in the broad area of the south end, as well as the area toward the island. The abundance of growth also is notable in that EWM completely fills a crib box, at least for those cribs where we can recognize the box outline from the lake surface.

Populations in cribs also have been observed to grow to the lake surface with both vegetative and flowering shoots (top out) more rapidly than the majority of those observed at GPS coordinate sites. However, EWM does not top out in all cribs each year, so in this way they may be similar to GPS site populations.

It is not clear what conditions contributed to the contrasting pattern of development in which EWM establishes itself in cribs but does not become established in marl in the immediate proximity of cribs.

Presence of EWM in cribs has contributed to an improvement in biological habit. Fish of different sizes frequent the cribs, and people do fish at or near the cribs. Although we have not searched for aquatic organism diversity at cribs, most probably many organisms are present at the cribs.

Several observations help to explain the rapid spread of EWM to the cribs, yet do not explain the apparently slow spread of EWM from its initial central site of invasion in the lake. Autofragmentation, and chopping off of shoots by motorcraft, may have contributed to the phenomenon, along with frequent windy conditions on the lake. When EWM patches top out--both vegetative and flowering shoots become abundant at the lake surface--vegetative shoots readily develop roots along their axes. Such rooted shoots separate from the plant and then drift about as floating shoots. They are capable of establishing new plants at other locations in the lake. If such shoots become entangled in a crib, it could establish a growing plant.

Windy conditions on the lake may aid establishment, such as in cribs. Storms disturb bottom sediments, especially from barren bottom, and bring them up into the water column. This condition is very evident on the lake during a storm; it takes a day or two for them to settle out. These sediments undoubtedly settle in cribs, as elsewhere, and may aid the rooting of plantlets washed into cribs. The rapidity of EWM growth could exceed that of native plants, whereby EWM could dominate the new growth area in the crib.

It is important to note, however, that autofragmentation does not lead to rampant spread of EWM in Kangaroo Lake. It does not result in its establishment along shorelines especially sandy shoreline. It does not result in EWM becoming established among fallen trees along the shoreline, such as along the wooded shoreline of the island or the south end.

During several recent years autofragmentation resulted in considerable EWM being accumulated along shorelines. Landowners removed wheelbarrel loads and even pickup truck-loads of material. Yet no EWM became established at those locations. There have been very few instances where an EWM became established near a shoreline, but such cases are rare considering the quantity of fragmented EWM that is blown onto the shoreline. So it is necessary for us to identify factors necessary for fragments or other parts to effectively become established in a new location. What factors are essential for establishment?--water depth, type of soil, nutrients, an object to entangle the plant, time of year, or other conditions?

However, there is one exception to the above comment. EWM fragments do establish themselves along the shoreline of the causeway especially on the north side of the causeway. The causeway area has been an especially difficult area and problem related to the control of EWM, and is currently under study.

It also is not clear how the character of the bottom supports the spread of EWM. We distinguished between four types of lake bottom--marl, sand, gravel and rock. The GPS coordinate sites were mostly marl. Thus, there are many more such sites in the lake than the other types of bottom. Yet EWM, apparently, is not spreading rapidly to other marl sites. Why did it spread so rapidly into cribs with their odd, woody presence rather than onto marl sites nearby?

It has established itself on a rocky reef at one location in the lake, near crib 16, but it is absent from the rocky reef near crib 9. Both sites are in open water, and EWM undoubtedly has floated across both reefs.

EWM flowers in Kangaroo Lake, but I do not know if it sets seed. Auto-fragmentation, however, provides vegetative materials far in excess of seed stock to establish new populations within the lake.

Kangaroo Lake was included in a biocontrol study to evaluate the effect of the milfoil weevil (Euhrychiopsis lecontei) on attacking EWM. It was not effective for Kangaroo Lake. The weevil did not over-winter successfully. Perhaps the biology of the shoreline did not aid survival, and lake size made it difficult for the weevil to travel to and from EWM.

Bladderwort. The recorded increase in the bladderwort population during the three samplings is also supported from visual observations on the lake. I could recognize an increased abundance of this plant. It survives the decreased clarity of the water, related to suspended algae, and forms very robust plants. It reproduces vegetatively in our study area. I have not observed flowers in our study area, but have seen them in the north lobe in quiet areas. If plants are pulled up and then returned to the water, or broken as during fishing, they will continue to grow. Released plants will float for a time, but then slowly drop to the bottom and re-root.

For vegetative reproduction of bladderwort, the shoot tips form turions, or overwintering buds, consisting of a shoot tip with shortened internodes along with many leaves--something like an onion bulb. To test their effectiveness, in mid-October of 2011, I collected 50 turions into a weighted18-inch diameter mesh bag and placed it in 3 feet of water for over winter. In spring after the ice went off the lake I retrieved the bag and tied it to my pier to watch development. As the water warmed, all turions had survived, began to grow and form roots. I released them and did not watch them further. I observed that bladderwort plants growing throughout our study area, such as in wind-prone areas in the middle of the lake, will form turions as will those is less windy bays such as at GPS site 501. I am not familiar with how weather conditions affect the number of turions formed during the season.

Other plants. It remains to be determined from future surveys whether the variations in the number of occupied sites for a particular species, as bladderwort, represents a variable that would be detectable over many years, or whether it is indicative of a long-term change in population size for a species in an aquatic environment. It is currently unclear whether the combined occurrence of EWM with bladderwort influences the growth and density of either plant.

The role of each plant in relation to EWM could be examined individually. The apparent increase of large-leaf pondweed is a particular point. Similarly, a comparison of chara for our study period, as well as its role in bottom stabilization, may be important. Chara occupies a significant area of the lake bottom. What role does it play in bottom stabilization and wave-related movement of sediments into the water column? Chara grows in water at all depths which may be a significant point for its survival in relation to EWM.

Summary. This information on the distribution of EWM in the south basin of the lake can provide the basis for developing a plan to manage EWM in Kangaroo Lake. We present them here for your review and further discussion.

We believe that we have been successful in improving fish and biological habitat in general with the installation of cribs. The rapid invasion of the cribs by EWM was unexpected. At present EWM occupies crib areas. It is unclear whether EWM will affect the area around a crib and expand widely in the lake.

Addendum. Our GPS data collection procedure was similar and repetitious throughout this study. We used a small open 14- or 16-foot highly maneuverable outboard motorboat. Two identical GPS instruments guided us to sites, one used by the operator and the other by the recorder at the front of the boat. GPS unit could detect a spatial difference between these two people in the boat. The collector was in the middle of the boat. The open boat enabled him to reach over the side close to the water so as to manipulate the rake with its long handle, marked at foot intervals, to collect a sample.

We sampled sites in a sequentially pattern across the lake. The operator maneuvered the boat slowly on a course toward each site, both instruments constantly recording progress. I readied the rake as we approached a recording site.

When the recorder's GPS crossed the coordinates, the operator put the motor into neutral, and I then thrust the rake down to the bottom to collect the sample. I called out lake depth and character of the lake, and brought up the plant sample for examination. I then called out the code words for EWM density and for each plant so the recorder could enter the information on our data sheets. Other points of interest, if any, also were noted. The operator then put the motor in gear to move on to the next site. If we were off-course on our approach to a site, the operator circled or otherwise changed course to re-approach the site.

The collection process is time-consuming and tiring. We typically worked without a break for 3 or 4 hours for one day, weather permitting. The same three people did the collection for 2006, 2008 and 2010. Thus our work ethic became more efficient with each collection year. In 2010 we three worked on the lake for four time-periods, and I worked periods alone on the lake to sample isolated locations. Total time to sample the 530 sites was about 80 hours for all of us.

We consider our procedure to be accurate and repeatable although we realize that the rake tip does not touch the exact same bottom point for each sampling year. We are within the capabilities of our GPS instruments, and their readings are quite reproducible. For example, many times for several summer I intentionally motor out to the coordinates of a known crib location. I find when at the site that I am within a boat-length of the crib, or directly over it. We are confident that successive samplings at a given GPS site are within a number of feet of each other.

References.

NES Ecological Services. 2004. Kangaroo Lake Comprehensive Lake Management Study, 39 pages plus figures. Green Bay, WI.

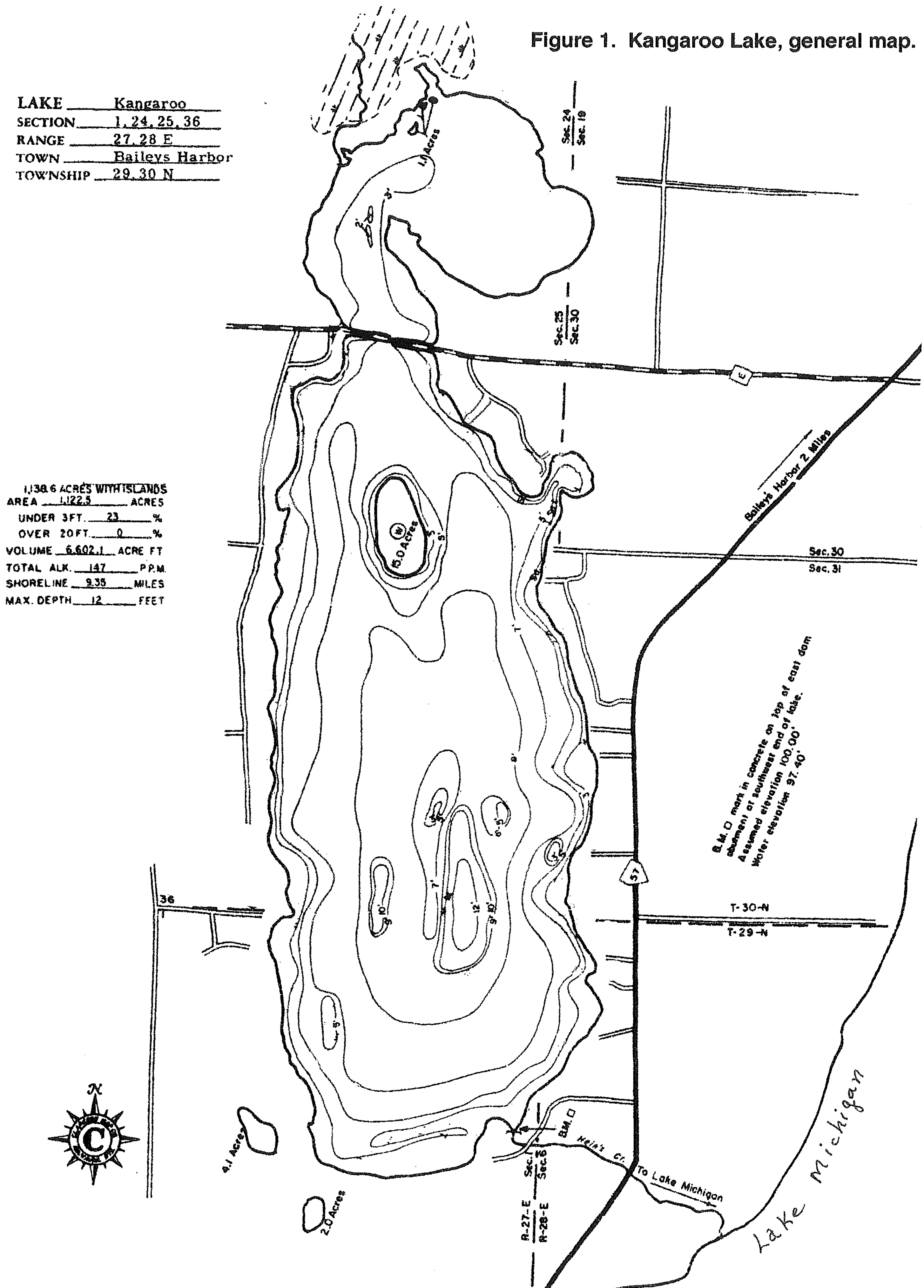
Gansberg, M. and T Hoymann. 2003. Sensitive area designation report. Kangaroo Lake, Door County, pp. 1-24. WDNR, Green Bay, Wisconsin.

Jester, L. 1998. The geographic distribution of the aquatic milfoil weevil (Euhrychiopsis lecontei) and factors influencing it density in Wisconsin lakes, 78 p. Masters thesis. NRCNR, University of Wisconsin, Stevens Point, WI.

Kangaroo Lake Study

List of Figures and Tables.

Figure 1. Kangaroo Lake, general map.



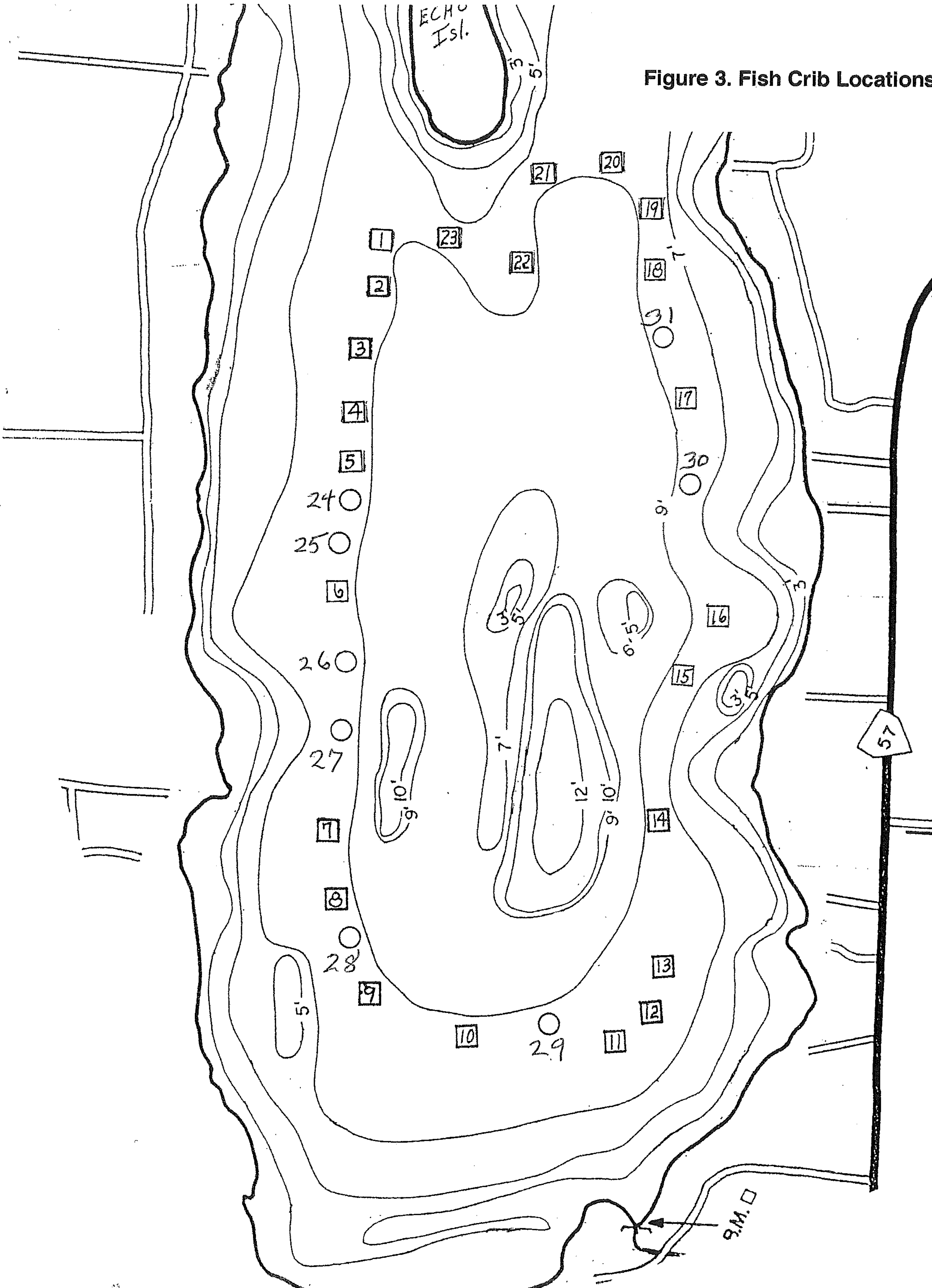


Figure 3. Fish Crib Locations.

Kangaroo Lake Study

Table 4. Eurasian Water-milfoil in Fish Cribs. Year: 8 - 2010

NUMBER	NAME	GPS LOCATION		EWM
1.	Thompson	N 45° 02.202	W 87° 09.739	Filled
2.	Glennon	N 45° 02.137	W 87° 09.739	Filled
3.	Malenius	N 45° 02.121	W 87° 09.741	Filled
4.	Madigan/Bell	N 45° 02.055	W 87° 09.726	Filled
5.	Quinnies	N 45° 01.975	W 87° 09.735	Filled
24.	Year 2003	N 45° 01.897	W 87° 09.691	Filled
25.	Year 2003	N 45° 01.806	W 87° 09.721	Filled
6.	Jerovitz	N 45° 01.720	W 87° 09.698	Filled
26.	Year 2003	N 45° 01.646	W 87° 09.707	Filled
27.	Year 2003	N 45° 01.570	W 87° 09.714	Filled
7.	Rushes WF	N 45° 01.504	W 87° 09.741	Filled
8.	Rushes WF	N 45° 01.394	W 87° 09.688	Filled
28.	Year 2003	N 45° 01.323	W 87° 09.614	Filled
9.	Rushes WF	N 45° 01.275	W 87° 09.545	Filled
10.	Smigielski	N 45° 01.290	W 87° 09.412	Filled
29.	Year 2003	N 45° 01.281	W 87° 09.316	Filled
11.	Schoof/Bezold	N 45° 01.304	W 87° 09.234	Filled
12.	Walt/M Schoof	N 45° 01.332	W 87° 09.188	Filled
13.	Livengood	N 45° 01.361	W 87° 09.166	Filled
14.	Cypert/Mahlberg	N 45° 01.536	W 87° 09.225	Filled
15.	Lipowski	N 45° 01.738	W 87° 09.183	Filled
16.	Frelly	N 45° 01.780	W 87° 09.135	Filled
30.	Year 2003	N 45° 01.895	W 87° 09.203	Filled
31.	Year 2003	N 45° 02.014	W 87° 09.240	Filled
17.	Anschutz	N 45° 02.127	W 87° 09.309	Filled
18.	Gissell/Keene	N 45° 02.209	W 87° 09.345	Filled
19.	Meyer	N 45° 02.241	W 87° 09.352	Filled
20.	Kubiak	N 45° 02.239	W 87° 09.438	Filled
21.	A, D, G	N 45° 02.222	W 87° 09.491	Filled
22.	Mahlberg	N 45° 02.186	W 87° 09.631	Filled
23.	Steldt	N 45° 02.210	W 87° 09.675	Filled

Table 5. EWM Density Among 530 GPS Sites In Each Survey, And In 31 Cribs.

EWM Density	2006	2008	2010	Cribs in 2010
0	476	456	494	-
1	29	15	18	-
2	10	6	7	-
3	15	16	11	31
Total EWM sites:	54	74	36	31

Table 6. Aquatic Plant Distribution Among 530 GPS Sites In Each Survey.

Plant	2006	2008	2010
None	116 (21%)	152 (28%)	106 (20%)
A = alga	48	41	68
B = bladderw	120	123	142
C = chara	287	289	315
N = naiad	128	30	58
P = pondw	78	90	64
Pl = large pondw	5	0	31

Table 7. Bottom Character Among 530 GPS Sites In Each Survey.

Type	2006	2008	2010
Marl	481	479	468
Sand	17	7	26
Gravel	3	4	5
Rock	29	40	31