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Inventory and Evaluation of Inland Fisheries at Sleeping Bear Dunes National Lakeshore

Prepared by
Brett Fessell, Grand Traverse Band Ottawa and Chippewa Indians
Natural Resources Department, 2605 N. W. Bayshore Drive, Suttons Bay, MI 49682
(231)-534-7655
brett.fessell@gtbindians.com

Principal Investigators
Joan Elias, National Park Service Great Lakes Inventory and Monitoring Network and Jay Glase, Midwest Regional Office, National Park Service; in collaboration with Brett Fessell, Grand Traverse Band Ottawa and Chippewa Indians, Natural Resources Department.





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ON THE COVER
Seining for fish in Florence Lake, small mouth bass from Lake Manitou (photos by Paul Murphy).

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Great Lakes Inventory and Monitoring Network Report GLKN/2007/03

Brett Fessell
Grand Traverse Band Ottawa and Chippewa Indians
Natural Resources Department
2605 N. W. Bayshore Drive
Suttons Bay, MI 49682

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U.S. Department of the Interior
National Park Service
Great Lakes Inventory and Monitoring Network
2800 Lake Shore Drive East
Ashland, WI 54806

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Problem Statement

The Sleeping Bear Dunes National Lakeshore (SLBE) is comprised of 28,809 ha (71,189 ac) in northwest lower Michigan and contains at least 19 inland lakes that offer fisheries accessible to the public. A survey of fishes at Sleeping Bear Dunes National Lakeshore was conducted in 1979 (Kelly and Price 1979). Since this 1979 survey, zebra mussels (*Dreissena polymorpha*) have invaded SLBE. Zebra mussels first invaded Lake Michigan in the late 1980s, and by 1995 mussels had washed up on the beaches of SLBE (S. Yancho, pers. comm.). The zebra mussels then spread to some of SLBE's inland lakes and currently occupy Loon Lake, Otter Lake, Bass Lake (in Benzie County), and North Bar Lake (S. Yancho, pers. comm.). Zebra mussels cause complicated and poorly understood cascading trophic effects and other alterations of aquatic faunal communities (e.g., Dermott and Kerec 1997; Gonzalez and Downing 1999; Indrisi et al. 2001; Lozano et al. 2001). SLBE staff have noticed thick blooms of *Cladophora* algae along the Lake Michigan shoreline in areas where zebra mussel colonies exist (S. Yancho, pers. comm.).

Staff at SLBE identified the need for a thorough inventory of fishes in SLBE inland lakes and streams before zebra mussels significantly alter fish species composition. Because only approximately 75% of the fishes currently on the SLBE species list have been verified, a survey of fishes in SLBE was also a priority of the National Park Service Great Lakes Network Office. Some lakes associated with SLBE are not entirely within the park and therefore were not included in the scope of work of this report. Table 1 is a partial list of waterbodies in SLBE as cited in the SLBE Water Resources Management Plan, with corresponding surface areas and depths where known. The list does not include streams or small bodies of water such as old farm ponds and inter-dunal ponds.

Objectives

A total of 76 fish species, 10 of which are exotic, were identified in the 1979 inventory, with the greatest diversity found in the stream systems within SLBE. Five gamefish families were represented: Centrarchidae, Esocidae, Ictaluridae, Percidae, and Salmonidae. In an effort to supplement existing surveys and maintain current records on lake evaluations the Grand Traverse Band Ottawa and Chippewa Indians, Natural Resources Department (GTB-NRD) performed fishery surveys on lakes within SLBE. We collected fish community information including presence/absence, species richness and diversity, and size and age class data in the streams, inland lakes, and selected Lake Michigan shoreline areas of SLBE. In addition, we surveyed the Aral Springs, wetland areas near Peterson Road, and other small waterbodies not considered to contain fisheries valuable to the public. Unidentified species had been visually observed in some of the Aral Springs and wetland areas, but had not been verified prior to this inventory (S. Yancho, pers. comm.).

Table 1. Surface area and depth of inland lakes, from SLBE Water Resources Management Plan (Vana-Miller 2002).

Waterbody	Area (ha)	Depth (m)
Big Glen (Partially in Park)	1979	39.6
Little Glen (Partially in Park)	574	4.3
Long (Partially in Park)	132	6.1
Manitou (North Manitou)	104	13.7
School	71	4.0
Shell	41	4.0
Bass (Leelanau County)	38	7.3
Loon	37	19.5
Florence (South Manitou)	32	7.9
Otter	26	6.4
Mud	21	0.2
Narada	13	11.9
North Bar	12	9.4
Bass (Benzie County)	11	7.9
Tucker	7	2.7
Round	6	7.9
Bow Lakes (Total of 3)	5	
Tamarack (North Manitou)	4	2.7
Day Mill Pond	2	1.2
Deer	2	6.7
Taylor	1	
Hatt Pond	1	0.3
Hidden Pond	1	0.2

Methods

Researchers used a combination of fish sampling techniques, including gillnets, fyke nets, boom and backpack electro-shockers, minnow traps, and seines. Sampling began in the spring (April - May) and continued throughout the summer and fall. Michigan Department of Natural Resources (MDNR) protocols were utilized to the greatest extent possible to enhance data compatibility, but in instances where time was limited or where waterbodies did not contain significant fisheries we employed slightly reduced standardized efforts in order to maximize survey coverage throughout SLBE.

We did not attempt to generate population estimates. The information collected was used primarily to determine overall species presence and age and growth relationships of gamefish for comparison with State average information. We pulled one to seven seines and set two to four fyke nets and one to two gillnets for one to two nights per lake depending on lake size and habitat characteristics (Table 2). At least 13 minnow traps were also set in littoral areas of each lake. In addition to age and growth analysis, catch per effort (CPE) was determined from each sampling with electrofishing gear, fyke nets, and gillnets for comparison with State averages.

Table 2. Gear types and netting effort by lake size.

Lake Size (ha)	Gear Types	Netting Effort	Number of Lakes
1-10	2 fyke, 1 gill, 1 seine	1 night	8
10-100	2-3 fyke, 1-2 gill, 1-2 seine	1-2 nights	12
100-1000	3 fyke, 1-2 gill, 2-3 seine	2 nights	3
1000+	4 fyke, 2 gill, 2-3 seine	2 nights	2

Fish Sampling Gear

Streams were sampled with backpack electro-shocker, seines, and minnow traps; fyke nets were also used in larger streams where feasible. We sampled reaches based on geomorphic differences within each stream and included various habitat types in each sampling section. A minimum of 455 m (500 yd) was sampled in each stream where multiple sections comprised the full length of the survey reach.

Gillnets consisted of five 7.6 m (25 ft) panels with mesh sizes including 12.7, 19.1, 25.4, 38.1, and 50.8 mm (0.5, 0.75, 1.0, 1.5, and 2.0 in) bar measure. These nets duplicate gear used in surveys conducted by Kelly and Price (1979). Gillnets were used in the deepest water of the larger lakes unless dissolved oxygen concentrations were <2.0 mg/L, in which case they were not deployed. Gillnets were fished on the bottom.

Fyke nets were of two sizes, including 0.9 x 1.8 m (3 x 4 ft) frame and 0.9 m (3 ft) hoops with 25.4 mm (1 in) bar measure mesh, and 0.6 x 0.9 m (2 x 3 ft) frame with 0.6 m (2 ft) hoops and 6.4 mm (0.25 in) bar measure mesh. Fyke nets were set perpendicular to shore on all lakes and large rivers where it was possible to set this net type.

Boom style electro-shocking was conducted at night in the littoral areas of Long and Loon Lakes to supplement netting surveys and to help evaluate whether the netting surveys effectively

collected a representative sample of species present in these lakes. This sampling occurred in August 2004. Boom shocking occurred in shallow water (1-2 m [3.3-6.6 ft] depth), at a slow steady speed, following MDNR protocol.

Backpack electro-shocking was conducted in randomly selected stream sections of Shalda, Narada, Otter, and Good Harbor Creeks. We also used backpack shocking in the Aral Springs area adjacent to Otter Creek. Backpack electro-shocking was also used from canoes in small ponds or lakes that restricted deployment of nets. These included Hatt, Hidden, Beck, Esch Road, and Taylor ponds, in addition to the inter-dunal flooding near Peterson Road and Mud Lake. The length of each stream shocking site was approximately five to ten channel widths (MDNR protocol), unless available habitat was not present in five to ten channel width sections. In these cases, individual habitat units such as pool, riffle, and run were sampled.

Minnow traps were used in all lakes, ponds, streams, and rivers. They were set on the bottom in littoral areas <1 m deep; they were baited with several pellets of dog food. (Narada Lake, Tucker Lake, Day Mill Pond, and Otter Creek mouth were sampled previously with minnow traps).

Seining was conducted at the mouths of Shalda Creek, Good Harbor Bay, and Otter Creek, and on firm substrates within inland lakes and streams. Seine lengths were 7.6 m (25 ft) for inland lake and Lake Michigan sites; stream seining was conducted in individual habitat units, and seine length was determined by length of units sampled.

All gamefish collected were identified to species, measured (total length to nearest mm), counted, and released alive with the exception of samples of small fish that could not be identified in the field, voucher specimens, and samples for contaminant testing. Non-gamefish were counted but not measured. Voucher specimens and small fish that could not be identified in the field were fixed in 10% formalin solution, preserved in 70% methanol, and identified to species in the lab. Digital photos of individual fish were taken for voucher and future reference purposes.

Dead and moribund fish caught in gillnets were discarded in an appropriate manner or used for contaminant sampling. Ten individuals of each of two species, brown bullhead and northern pike, were collected from Tucker Lake for contaminant testing. We followed Michigan Department of Environmental Quality (DEQ) protocol for collecting and holding fish for contaminant sampling, and MDNR protocol for disposing of dead fish that were not used for contaminant sampling. Whenever possible, we attempted to use freshly-dead or moribund fish from gillnets for contaminant testing, rather than healthy fish.

Age data were obtained through scale and/or spine collection on all gamefish species. We collected scales from up to five fish per 25 mm (1 in) size class for all gamefish over 102 mm (4 in) in length. Scales were analyzed by GTB-NRD fisheries staff to determine length at age.

Water quality data were collected with a Hydrolab® multi probe, Secchi disc, and Hach kits. We measured depth, temperature, dissolved oxygen, pH, turbidity, specific conductance, total dissolved solids, sulfate, nitrate, ammonia nitrogen, color, hardness, calcium hardness, and alkalinity. General habitat notations including bottom composition, woody debris abundance,

and aquatic plants were recorded in conjunction with fish surveys. All data were summarized on field forms approved by the National Park Service.

As time permitted while conducting fish sampling, researchers added to the Lakeshore's species lists for aquatic plants, mussels, crayfish, herpetofauna, and other aquatic organisms by noting species presence, collecting vouchers, and/or documenting via photograph. To prevent potential introduction of exotic species into the lakes to be surveyed, all boats, motors, and fishing gear were treated with 5% salt solution (3/4 cup salt per gallon of water) prior to accessing each waterbody. Fyke nets and equipment that could not be submerged in solution were thoroughly cleaned with exposure to sunlight until completely dry for at least one day. After surveys and upon exiting the waterbody, all vegetation was removed from boat motors and trailers.

Fishery Interpretation

Most of the lakes surveyed within SLBE are classified as warmwater and coolwater lakes where dominant species commonly include bluegill, largemouth bass, crappie, carp, bowfin, yellow perch, smallmouth bass, walleye, rock bass, northern pike, and white sucker (Schneider 2000). Undesirable lake communities, and often poor fishing quality, are generally indicated by the following percentages by weight (Schneider 1981):

- Common carp or white sucker >50%
- Bluegill + pumpkinseed >78%
- Minnows + chubsucker + warmouth >15%
- Predators <20% and >50%

Though weights were not taken during the fishery surveys, we used these percentages as guidelines for interpreting community parameters using numbers caught.

As a rule, bluegill is a key species in management of warmwater lakes (Schneider 2000), where, generally speaking, a quality bluegill fishery in a lake tends to reflect satisfactory fishing quality for the lake as a whole (Schneider 1981). It is important to note that lakes with stunted bluegill populations can often produce exceptionally large bass. Schneider (1981) recommends the following additional population indices for bluegill:

- Presence of any 203 mm (8 in) bluegill indicates a relatively good population;
- Absence of 203 mm (8 in) bluegill, coupled with a bluegill growth index more than 25.4 mm (1 in) below State average, indicates unsatisfactory conditions.

Growth indices for other species were presented (in inches) when adequate data were available. Generally, growth indices within ± 1 in of State averages were considered satisfactory.

As an additional interpretive tool, we used an empirical scoring system developed by Schneider (1990) that used length-frequency statistics of bluegill sampled by several types of gear used in Michigan. The length-frequency indices used were average length and proportion of the catch larger than 152 mm (6 in), 178 mm (7 in), and 203 mm (8 in). The scoring system simply characterizes bluegill population characteristics over seven ranking scores from “very poor” to “superior”. Additionally, we included growth indices of predatory gamefish if sufficient data

were available to perform calculations. All statistics and interpretations are presented by lake in tabular form and include species collected using fyke nets, gillnets or electrofishing, but not species collected from seines or minnow traps.

Stream fisheries were evaluated using an Index of Biotic Integrity coupled with a general fishery quality analysis. Three streams were evaluated in 2003 and three streams in 2004, most of which could be considered warmwater or intermediate trout streams. Further definition of analysis methods and stream characterizations are discussed in each stream's respective section below.

Results and Discussion

A total of 35 waterbodies or sites were surveyed in 2003, 2004, 2005, and 2006: Good Harbor Creek, Shalda Creek, Narada Lake, School Lake, Bass Lake (Leelanau County), Shell Lake, Tucker Lake, Tucker Creek, Day Mill Pond, Otter Creek, Otter Lake, Upper Otter Creek, Bass Lake (Benzie County), Hidden Pond, Hatt Pond, North Bar Lake, Lake Manitou, Florence Lake, Aral Springs, Taylor Lake, Beck Pond, Esch Road Pond, Deer Lake, Peterson Road Pond, Mud Lake, Loon Lake, Round Lake, Long Lake, Little Traverse Lake, Boekeloo Road Ponds, and Lake Michigan sites including Good Harbor Bay, Sleeping Bear Bay, Bar Lakes shoreline, Esch Road shoreline, and Platte Bay Lake Michigan Road (Figure 1). Species lists of fish captured in each lake from 2003 to 2006 relative to those observed in previous surveys are presented in Appendices A through I. Forty-six species were observed in the surveys and are listed by their common names in Table 3. Approximately 99% of the waterbodies within SLBE were sampled from 2003 to 2006.

Waterbodies that were not sampled during the 2003-2006 surveys are described in this report using the most recent data available. Additionally, explanations are provided as to why they were not surveyed. These waterbodies include Little Platte Lake, Lower Platte River, Bow Lakes, Rush Lake, and Tamarack Lake. Appendix J includes a list of scientific names of fishes referred to in this report.

Table 3. Fish species observed during 2003-2006 fishery surveys in SLBE.

Alewife	Coho Salmon	Mottled Sculpin
Banded Killifish	Common Carp	Northern Pike
Black Bullhead	Common Shiner	Northern Redbelly Dace
Black Crappie	Creek Chub	Pumpkinseed
Blacknose Dace	Emerald Shiner	Rainbow Trout
Blacknose Shiner	Fathead Minnow	Rock Bass
Bluegill	Golden Shiner	Round Goby
Bluntnose Minnow	Hornyhead Chub	Sand Shiner
Bowfin	Iowa Darter	Sea Lamprey
Brook Silversides	Johnny Darter	Smallmouth Bass
Brook Stickleback	Lake Whitefish	Spot-tail Shiner
Brook Trout	Largemouth Bass	Walleye
Brown Bullhead	Log Perch	White Sucker
Brown Trout	Longnose Dace	Yellow Bullhead
Central Mudminnow	Mimic Shiner	Yellow Perch
Chinook Salmon		

Further analysis of waterbodies is presented on an individual basis and categorized by major watershed including Shalda Creek, Crystal River, Otter Creek, and Lower Platte River. Gear types used, effort, and species composition are summarized on maps for each waterbody. The species composition for each waterbody is compared to findings of previous surveys dating back to the 1960s and 1970s. For waterbodies containing significant or potentially significant

recreational fisheries, growth and community indices are presented. Finally, recommendations to improve fisheries or ecological integrity of a system are given.

Shalda Creek Watershed

The Shalda Creek drainage includes Lime Lake, Shetland Creek, Little Traverse Lake, and Narada Lake. Also within this drainage, but without any significant surface water exchange with Shalda Creek, are School Lake, Bass Lake, Shell Lake, Hatt Pond, and Hidden Pond. Shalda Creek is a first order stream draining nearly level to gently sloping sandy soils and nearly level poorly drained mucky soils situated on lake terraces and beach ridges (Soil Survey of Leelanau County, Michigan 1973). These soils contain layers of gravel and coarse sand, which are evident in the streambed at various sites throughout the drainage. Only limited amounts of exposed gravel are present in Shalda Creek and are situated near the mouth and origin of the stream. Gravel substrates near the mouth are commonly used by spawning anadromous salmonids.

Shalda Creek is classified by the MDNR as a type 1 stream, which designates it as a trout stream open from the last Saturday in April to September 30 with size limits of 203 mm (8 in) for brook and brown trout and 254 mm (10 in) for rainbow trout and Pacific salmon. Average discharge is approximately 0.3 m^3/s (11 ft^3/s). We suspect that there is relatively little groundwater input to act as a temperature buffer in the extremes of summer and winter. Furthermore, because this stream is largely supported by surface water originating from Lime and Little Traverse Lakes and is frequently impounded by beaver, instream summer temperatures often exceed preferences for salmonids. Continuous temperature data from this stream show average summer temperatures for 1998 and 1999 of 21.0 and 21.2 ^{o}C, respectively. Maximum temperatures regularly exceeded 26 $^{\circ}$C in Shalda Creek (Figure 2). Thermal tolerances for steelhead, as measured by the Critical Thermal Maximum (CTM), range from 13.5 to 27 $^{\circ}$C depending on acclimation temperature. Steelhead acclimated to a 14 $^{\circ}$C cycling temperature regime (12$\pm$7 $^{\circ}$C) exhibited a temperature tolerance of 25 $^{\circ}$C in the laboratory (Houston 1982). It should be noted, however, that the CTM represents a temperature that eventually leads to the death of the fish, and constitutes inhospitable conditions for a given species if exposed on a regular basis. Salmonids in general can be physiologically stressed when instream temperatures regularly exceed the upper limit of their preferred temperature range (22 $^{\circ}$C) (Houston 1982; Sigler and Sigler 1987). Temperatures in Shalda Creek regularly exceeded both the CTM and the upper limit for preferred temperatures of both steelhead and Chinook salmon (Figure 2).

A backpack electrofisher was used to sample approximately 460 m (1,509 ft) of stream channel at four different locations in July 2003. Locations included sections upstream and downstream of Lake Michigan Road near the mouth, a section approximately 152 m (499 ft) below County Road 669, and a section at the outlet of Little Traverse Lake (Figure 3). Total shock time was 36 min. Additionally, one small mesh fyke net (0.6 x 0.9 m [2 x 3 ft]) was fished for one night. A total of 22 species were observed, including one brown trout and five rainbow trout (Figure 3). Longnose dace comprised the largest percent of the catch (38%), followed by rock bass (21%), emerald shiner (8%), and central mudminnow (8%). The presence of juvenile steelhead indicates limited recruitment of steelhead in some years depending on temperature regimes; however, the juvenile steelhead that were observed were within 152 m (500 ft) of Lake Michigan where thermal refuge may be available during elevated temperature episodes.

Stream fish communities in Michigan have been evaluated using an Index of Biotic Integrity (IBI) (Karr 1981; Karr et al. 1986). The IBI is a multimetric index that rates the existing structure, composition, and functional organization of the fish assemblage with regional and habitat-specific expectations derived from comparable high-quality ecosystems (Lyons et al. 1996). The index utilizes 12 metrics that describe fish community characteristics and allow biologists to evaluate fish communities quantitatively by assigning scores to individual metrics to yield an overall score for a site. The metrics described by Karr (1981), and later used in fishery evaluation protocols including MDEQ Procedure 51, were intended for low gradient, warmwater (maximum daily mean temperatures >24 ^{o}C) streams where species diversity and richness are the most significant indicators of biotic integrity.

We have found that the IBI developed by Karr and utilized by MDEQ does not apply well to coldwater (maximum mean daily temperatures <22 ^{o}C) trout streams typically found in northern Michigan. Lyons et al. (1996) recognized this shortcoming and developed a modified 5 metric IBI better suited for evaluating coldwater trout streams where species diversity and richness are generally low. Shalda Creek appears to fit somewhere in between the coldwater and warmwater designation. Due to the lack of resident salmonids coupled with the presence of a large diversity of fishes, we used the 12 metric IBI, as tested by Lyons (1992) in Wisconsin, to evaluate the biotic integrity and environmental quality of Shalda Creek.

In comparison to streams of similar width in northern Wisconsin that empty into Lake Michigan, Shalda Creek scored 65 out of 100, based on the number of native species, darter species, sucker species, sunfish species, intolerant species, percent intolerant species, percent omnivores, percent insectivores, percent top carnivores, percent simple lithophilous spawners (require clean gravel for spawning and do not build a guarded nest), number of individuals per 300 m section of stream, and percent individuals with deformities. Intolerant species are sensitive to several types of environmental stress and tend to be absent in environmentally degraded systems. Tolerant species are able to persist in a wide range of environmental conditions and tend to be quite common in highly degraded environments (Lyons et al. 1996). The IBI score assigned to Shalda Creek would be rated as “excellent” according to the ratings as interpreted by Lyons (1992) (Table 4).

From a fishery standpoint the IBI is limited in that it does not allow for clear interpretation of sport fishery quality. Standing stock, age class composition, growth, and recruitment are typically measured to help evaluate sport fisheries in streams. The only significant sport fisheries provided by Shalda Creek are the product of anadromous salmonid runs in spring and fall; however, season closures limit access to these fisheries. Because the survey was conducted in July, only limited data on recruitment were obtained. Very few juvenile steelhead were found in Shalda Creek, and juvenile Chinook salmon would have left the stream prior to our survey. Additionally, the most abundant species found during our survey were generally pisciverous (fish-eating) warm/cool water species including small mouth bass, rock bass, largemouth bass, northern pike, bowfin, and yellow perch. This species composition, in general, would not be conducive to steelhead trout recruitment and also suggests that water temperature regimes may regularly exceed those preferred by steelhead.

Table 4. Guidelines for interpreting overall IBI scores (modified from Karr et al. 1986).

IBI Score	Integrity Rating	Interpretation and Fish Community Attributes
65-100	Excellent	Comparable to the best situations with minimal human disturbance; all regionally expected species for habitat and stream size, including the most intolerant forms, are present with a full array of age and size classes; balanced trophic structure.
50-64	Good	Species richness somewhat below expectation, especially due to the loss of the most intolerant forms; some species, especially top carnivores, are present with less than optimal abundances or size/age distributions; trophic structure shows some signs of imbalance.
30-49	Fair	Signs of additional deterioration include decreased species richness, loss of intolerant forms, reduction in simple lithophils, increased abundance of tolerant species, and/or highly skewed trophic structure (e.g., increasing frequency of omnivores and decreased frequency of more specialized feeders); older age classes of top carnivores rare or absent.
20-29	Poor	Relatively few species; dominated by omnivores, tolerant forms, and habitat generalists; few or no top carnivores or simple lithophilous spawners; growth rates and condition factors sometimes depressed; hybrids sometimes common.
0 or no score	Very Poor	Very few species present, mostly exotics or tolerant forms or hybrids; few large or old fish; DELT fish (fish with deformities, eroded fins, lesions, or tumors) sometimes common. OR Thorough sampling finds few or no fish; impossible to calculate IBI.

Shalda Creek likely provides little steelhead production to the Great Lakes, yet does sustain significant runs of fish in the spring of the year. Chinook salmon production is likely more significant than steelhead and also provides a measurable fishery to anglers. Limited numbers of anadromous brown trout also use this stream for spawning and may reside in the stream in years where temperatures are not excessive. Fishery quality to the public would improve if the stream designation were changed to type 3 to allow greater access to Chinook and steelhead fisheries. This change would have no significant impact on steelhead and Chinook populations in general. Kelly and Price (1979) indicated that the US Fish and Wildlife Service (USFWS) has surveyed this stream on almost an annual basis since 1960 as part of their sea lamprey control program. During those surveys they have observed 35 species of fish, including 10 species observed by Kelly and Price (1979). Including the survey by Kelly and Price, the USFWS surveys, and the 2003 NPS survey, a total of 39 species have been observed in surveys since the 1960s (Appendix A). Species observed by the USFWS or Kelly and Price (1979) but not observed in 2003 include chestnut lamprey, sea lamprey, brook trout, Chinook salmon, coho salmon, rainbow smelt, blacknose dace, blacknose shiner, northern redbelly dace, sand shiner, ninespine stickleback, slimy sculpin, largemouth bass, fantailed darter, log perch, and yellow perch. Species observed in 2003 but not in any other previous surveys listed in Kelly and Price (1979) include bowfin, hornyhead chub, and pumpkinseed. Many of the species listed from previous surveys but not

observed in 2003 are common and known to exist currently in the system at least during portions of the year. These include Chinook salmon, coho salmon, rainbow smelt, slimy sculpin, largemouth bass, and yellow perch. Other species such as lampreys, blacknose dace, blacknose shiner, northern redbelly dace, sand shiner, ninespine stickleback, fantailed darter, and log perch require further surveys to determine their persistence in the system.

Little Traverse Lake

Little Traverse Lake is 261 ha (640 ac) largely surrounded by a mixture of upland hardwoods and conifers with thinly distributed aspen and birch, on nearly flat to gently sloping contours. At both the east and west ends of the lake, lowland conifers dominate on flat hydric soils. Bottom composition is chiefly soft marl and sand with sparse gravel pockets throughout. Bottom contours generally follow upland topography trends with the steepest drop-offs along the north shore of the lake. Average depth is approximately 8 m (25 ft) with a maximum of 16.5 m (54 ft). The shoreline has limited complexity (uniform and linear) with relatively gentle slopes to the water's edge. Approximately one-half of the shoreline is developed and absent of nearshore vegetation. Nearshore areas that are vegetated are dominated by bulrush *(Scirpus sp.)*, and scattered sedge *(Carex sp.)* and cattail *(Typha sp.)* colonies. The littoral zone is largely absent of large woody debris or submerged macrophytes, and existing patches are comprised chiefly of pondweed (*Potamogeton sp.)* and muskgrass *(Chara vulgaris)*.

Though not physically situated within SLBE, the lake has significant influence on waters within the Lakeshore. Public access at the western end of the lake receives significant recreational use for fishing and water sports. The lake is supplied largely by groundwater originating from the watershed of Lime Lake, which is situated to the south and is connected by Shetland Creek. Little Traverse Lake is also fed by a few small tributaries within its basin and ultimately empties into Lake Michigan via Shalda (Sucker) Creek. A stream survey on August 5, 1998, estimated the discharge of Shalda Creek at 0.28 m^3/s (10.2 ft^3/s). Water quality parameters measured on August 5, 2005, revealed nothing remarkable. Temperature and dissolved oxygen at the surface were 25.6 $^{\circ}C$ and 7.5 ppm, respectively. Temperature and dissolved oxygen at the bottom (15.2 m [50 ft]) were 15.8 $^{\circ}C$ and less than 1 ppm. The lake was stratified with the thermocline observed at approximately 9 m (30 ft).

Fishery surveys were performed July 25-29, 2005, using fyke nets, seines, and minnow traps. We sampled 45 net nights (10 large mesh nets and five small mesh nets fished over three nights), and 18 minnow traps were fished for one night. Seven seine hauls were conducted at various locations throughout the lake (Figure 4). A total of 19 species were collected: smallmouth bass, pumpkinseed, yellow perch, rock bass, brown bullhead, northern pike, largemouth bass, bowfin, bluegill, common shiner, bluntnose minnow, Johnny darter, banded killifish, sand shiner, white sucker, hornyhead chub, log perch, and mottled sculpin (listed in order of abundance). Table 5 summarizes fishery indices used to help describe the lake's fish community. Smallmouth bass, pumpkinseed, yellow perch, and rock bass comprised the largest portion of the gamefish catch numerically: 28%, 24%, 20%, and 19%, respectively. Large numbers of young-of-year smallmouth bass were collected, and only 2% were over the 35.6 cm (14 in) legal size limit. The average length of smallmouth collected was 9.5 cm (3.7 in). Average lengths for pumpkinseed and yellow perch were 6.9 cm (3 in) and 10.9 cm (4 in), respectively. No pumpkinseed were over 12 cm (5 in), but nearly 19% of the yellow perch were over 17cm (7 in) with the largest at 32 cm

Table 5. Summary of community indices for Little Traverse Lake, Leelanau County (2005).

Lake Community Indices	Statistic	Interpretation
Number of Species Observed	19	
Bluegill Size Score	1	Very Poor
Bluegill Growth Index	na	na
Percent Bluegill/Pumpkinseed	24.0%	Acceptable
Presence of 203 mm (8 in) Bluegill/Pumpkinseed	None	Unsatisfactory
Percent Predators	3%	Unsatisfactory
Smallmouth Bass Growth Index	-2.5	Below State Average

(12.5 in). Rock bass averaged 9.5 cm (4 in) and 14.5% were over 15 cm (6 in). Thirty-seven brown bullhead were captured, with an average length of 18.9 cm (7 in) and the largest at 35 cm (14 in). Only 10 northern pike were captured, averaging 55 cm (22 in) with the largest at 71 cm (28 in). A strong and diverse forage fish base appears to exist in this lake.

Kelly and Price (1979) did not sample Little Traverse Lake; however, 13 species were observed during a MDNR fishery survey conducted in June 1995 investigating the success of bluegill and pumpkinseed plantings in the early 1990s. Alewife and rainbow trout were observed in 1995 but not in 2005. Alewife is a common species in deeper lakes with direct connection to Lake Michigan, and it is likely this species persists in Traverse Lake today. Rainbow trout are known to migrate up Shalda Creek in the spring and are periodically caught by anglers in the lake throughout the summer. It is likely these species were not captured because of high water temperatures during the 2005 survey period. All other species observed in 1995 were also seen in 2005. Species observed in 2005 but not in 1995 include bluegill, banded killifish, log perch, Johnny darter, sand shiner, hornyhead chub, and mottled sculpin.

Plantings of bluegill and pumpkinseed occurred in 1991, 1992, and 1993. Approximately 2,400 adult and yearling bluegill and 130 yearling pumpkinseed were stocked during this period. Very few pumpkinseed (four fish) and no bluegill were observed during the 1995 survey. We speculated that mortality due to parasitism was partly responsible for the lack of survival from the plantings. Reductions in vegetation may also limit the panfish. We captured only three bluegill age 0 and I (based on size classes). Pumpkinseed numbers, however, appeared to have increased in abundance since 1995. We captured 137 pumpkinseed representing three age classes including 0, I and II (based on size classes), with age I comprising the largest portion of the catch. Only one age class (II) had growth equal to the State average. Only two age classes of yellow perch yielded large enough samples to calculate a growth index, and it was significantly higher than State average (+2.3). It appears that growth of yellow perch in age classes III and IV has improved since the 1995 survey. Smallmouth bass continue to grow significantly below State average (-2.5), with this trend based on the age classes yielding large enough samples to calculate growth indices (I, II, and III). These data corroborate observations in 1995 where early age classes exhibited poorer growth than older age classes (>IV).

In 1995, only rock bass, yellow perch, and smallmouth bass yielded large enough samples to calculate growth indices. Rock bass and yellow perch were growing slightly below State

average, and smallmouth were growing slightly above. Ten age classes of smallmouth bass and yellow perch were observed.

Currently, Little Traverse Lake likely provides an average fishery. Bass and yellow perch appear to be its strongest fisheries, while the lake offers a variety of other gamefish species, including northern pike and bowfin, to challenge anglers. It is likely that shoreline development limits fisheries to an extent through removal of structure in the littoral zone. Nearshore habitat could be improved in the developed areas with increased frequency and abundance of large woody debris or whole trees, and natural revegetation on and near the shore. Further surveys are recommended to better evaluate growth and survival of gamefish species.

Narada Lake

Narada Lake is situated west of Shalda Creek and is connected to the creek via a small stream emerging from a large beaver dam at the east end of the lake. Motors are prohibited in this lake, and access is generally limited to canoes and very small boats. The shoreline exhibits moderate complexity (not highly convoluted) with an abrupt bank. A significant portion (nearly 50%) of this lake is comprised of flooded timber consequent to the beaver impoundment. Figure 5 illustrates the 6.5 ha (16 ac) main basin of the lake, surrounded by approximately 6 ha (15 ac) of inundated uplands and standing timber. As observed by Kelly and Price (1979), the lake bottom is chiefly soft muck with muskgrass covering most of the basin. Large beds of white and yellow water-lily (*Nymphaea odorata* and *Nuphar lutea*), in addition to pondweed, inhabit the shallower margins. The highest densities of lilies and pondweed are found within the flooded timber.

Fishery surveys were performed in October 2003 using a backpack electrofisher deployed from a canoe, fyke nets, gillnets, and minnow traps. We sampled 12 net nights (four fyke nets and two gillnets over two nights), and 13 minnow traps were fished for one night. A total of 11.3 min shock time was recorded. Eight species were collected: brown bullhead, largemouth bass, northern pike, rock bass, yellow perch, bluegill, pumpkinseed, and central mudminnow (listed in order of abundance). Figure 5 illustrates net and trap locations in addition to electrofishing courses. Table 6 summarizes fishery indices used to help describe the lake's fish community. In general, Narada Lake provides an average to below average fishery with limited growth of large predatory species. Panfish populations, particularly bullhead, are likely predator limited. No 203 mm (8 in) bluegill were observed. Brown bullhead comprised the largest portion (58%) of the catch, and very few soft-rayed forage fish were observed.

Bluegill and bass fisheries can benefit from a staggered year bullhead removal if sufficient nearshore structure is available and the fertility of the system is not particularly high (Waybrant, pers. comm.). A complex littoral zone exists with large amounts of woody debris including standing and fallen trees. Water quality data are still pending; however, like most lakes in this region, it is likely to have relatively low fertility due to the local prevalence of highly permeable mineral (sand and gravel) soils and groundwater contributions. This lake could be a candidate for a staggered year bullhead removal effort with subsequent periodic monitoring of gamefish growth and abundance.

Table 6. Summary of community indices for Narada Lake, Leelanau County (2003).

Lake Community Indices	Statistic	Interpretation
Number of Species Observed	8	
Bluegill Size Score	1	Very Poor
Bluegill Growth Index	Not Determined	Insufficient Data
Percent Bluegill/Pumpkinseed	7.0%	Acceptable, but Low
Presence of 203 mm (8 in) Bluegill	None	Unsatisfactory
Percent Predators	21%	Satisfactory
Largemouth Bass Growth Index	+0.42	Slightly Above State Average

Eight species were observed in the survey performed by Kelly and Price (1979), but the species differed from those we observed. Golden shiners were the most abundant species observed in 1979, though none were captured in 2003. Other species observed in 1979 but not in 2003 include alewife, white sucker, and brook stickleback. However, white sucker and brook stickleback were observed in Narada Creek as indicated below.

Narada Creek

Narada Creek is the discharge of Narada Lake, entering Shalda Creek to the east. It is a short stream (approximately 930 m [3,050 ft]) with several beaver dams influencing it throughout its course. Average width is approximately 8 m (26 ft) and depth of approximately 0.5 m (1.5 ft). Bottom substrates are largely sand and muck with significant accumulations of woody debris from beaver activity. It flows through lowland conifers and tag alders associated with the riparian zone of Shalda Creek. Its discharge is greatly influenced by the large beaver impoundment on Narada Lake.

The fishery survey occurred on May 12, 2004. A backpack electrofisher was used to sample approximately 100 m (328 ft) of the stream from the confluence with Shalda creek upstream (Figure 6). Deep water and unstable substrates hindered our ability to sample farther upstream. Shock time was approximately 20 min. A total of 12 species were observed: common shiner, creek chub, white sucker, bluntnose minnow, brook stickleback, blacknose shiner, central mudminnow, pumpkinseed, northern redbelly dace, bluegill, yellow perch, and Johnny darter (listed in order of numerical abundance). Species composition is more similar to that found in Shalda Creek than in Narada Lake, as the reach sampled was directly upstream from the confluence. Kelly and Price (1979) noted only creek chub in their survey; however, it is unclear where and how much effort was expended in this stream in 1979. Narada Creek is not a designated trout stream and should remain as such. It provides wildlife habitat for beaver, otter, and waterfowl.

School Lake

School Lake is 71.2 ha (176 ac) largely surrounded by relatively steep contours of upland hardwoods. The lake has a nearly flat, shallow, muck bottom, and averages about 1.5 m (5 ft) in depth. The only exception to the lake bottom topography is a small (approximately 1 ha [2.5 ac]) cove at the southwest end of the lake where steep banks drop to nearly 6 m (20 ft) below the surface in the center. The shoreline has limited complexity (uniform and linear) and is dominated by bulrush, sedge, and cattail colonies. Gentle slopes to the water's edge define much of the

shoreline. With the exception of the small cove, large woody debris is widely distributed and relatively low in abundance. Most of the lake bottom is absent of macrophyte cover except the south end of the lake where colonies of pondweed, coontail (*Ceratophyllum demersum)*, elodea (*Elodea canadensis)*, and water-lily cover the bottom. Water quality parameters measured in early June revealed nothing remarkable. Dissolved oxygen at the bottom 1.2 m (4 ft) of the cove was less than 3 ppm. The lake has a history of winterkill. This is one of few lakes within SLBE where motors are allowed, and access is very high.

Fishery surveys were performed in June 2003 using fyke nets, gillnets, seines, and minnow traps. We sampled seven net nights (three fyke nets for two nights and one gillnet for one night), and 16 minnow traps were fished for one night. A total of seven seine hauls were conducted in two general areas where the shoreline was wadeable (Figure 7). Nine species were collected: yellow perch, banded killifish, bluegill, brown bullhead, pumpkinseed, northern pike, largemouth bass, rock bass, and mimic shiner (listed in order of abundance). Table 7 summarizes fishery indices used to help describe the lake's fish community. Yellow perch, bluegill, and pumpkinseed comprised the largest portion of the catch numerically, 43%, 15%, and 6%, respectively. However, brown bullhead comprised the largest proportion of the catch in terms of biomass (estimated). Only one age class of bluegill had a large enough sample (>5) to calculate a growth index, which was slightly above State average. No 203 mm (8 in) bluegill were observed, and the population structure may be imbalanced. No other species or age class provided large enough samples for age indices to be calculated. In general, School Lake offers a poor fishery with growth of predatory gamefish lower than average. Only four age classes of northern pike were collected (six fish), all of which had smaller length at age than State average.

Nearshore habitat could be improved with increased frequency and abundance of large woody debris or whole trees. Bullhead removal may also benefit the fisheries. However, with its history of winterkills and current fish community composition, this lake will likely provide no more than a mediocre fishery without significant attention.

Table 7. Summary of community indices for School Lake, Leelanau County (2003).

Lake Community Indices	Statistic	Interpretation
Number of Species Observed	9	
Bluegill Size Score	1	Very Poor
Bluegill Growth Index	+0.04	Satisfactory (but only for one year class)
Percent Bluegill/Pumpkinseed	43.0%	Acceptable
Presence of 203 mm (8 in) Bluegill	None	Unsatisfactory
Percent Predators	3%	Unsatisfactory
Largemouth Bass Growth Index	Not Determined	Insufficient Data

Six species were observed in the 1979 survey, compared with nine species observed during our survey. Two species, bluntnose minnow and yellow bullhead, were seen in 1979 but not captured in 2003. Bluntnose minnow is a very common species, and it is likely this species persists in School Lake today. It is also possible that yellow bullhead are present as well. All other species observed in 1979 were also seen in 2003. Species observed in 2003 but not in any previous surveys listed in Kelly and Price (1979) include banded killifish, yellow perch, and mimic shiner.

As in 1979 very few minnow species were observed in 2003. Kelly and Price (1979) suggest that the minnow niche may be occupied by sunfish in both School and Bass Lakes. Young yellow perch likely occupy this niche as well. The only minnow species observed in School Lake was what appeared to be mimic shiner. School Lake was the first lake surveyed in 2003, and as surveys continued on other lakes it became apparent that samples of minnows with slightly different, often difficult to discern, meristics were being observed, making it difficult to distinguish between mimic shiners and sand shiners. Specifically, lateral scale dimensions "deeper than wide" were often observed, and the lack of a "distinct dark wedge" at the origin of the dorsal fin both suggest mimic shiner. However, most sampled minnows appeared to have seven anal fin rays, which suggests sand shiners. Consequently, observations of either species may suggest the presence of both in any particular lake or system.

Bass Lake

Bass Lake is 37.6 ha (93 ac) surrounded by similar topography and cover types as School Lake. It is periodically connected to School Lake when water levels are high through a small channel at the south end of the lake. Motors are prohibited in this lake, and access is generally limited to canoes and small boats. Bottom contours are dissimilar to School Lake in that average depth of the basin is approximately 3-4.5 m (10-15 ft) with the deepest point 7.3 m (24 ft). Bank contours exhibit moderate to sharp drop-offs with the sharpest located at the north end of the lake. Substrate composition is similar to School Lake where sand and muck are dominant with occasional small pockets of gravel. The shoreline is also similar to School Lake with limited complexity, sloped edges, sparse woody debris, and bulrush and cattail colonies. Macrophytes are relatively low in abundance and where any patches exist they are comprised chiefly of pondweed and muskgrass. Water quality parameters measured in early June revealed nothing remarkable. Dissolved oxygen and temperatures profiles taken on June 11indicated initial stages of stratification. It is not known whether this lake has a history of winterkill.

Fishery surveys were performed in June 2003 using fyke nets, seines, and minnow traps. We sampled nine net nights (three fyke nets for three nights), and 16 minnow traps were fished for one night. A total of seven seine hauls were conducted in several locations where the shoreline was wadeable (Figure 8). A total of 11 species were collected: white sucker, largemouth bass, banded killifish, brown bullhead, bluntnose minnow, bluegill, yellow perch, pumpkinseed, northern pike, rock bass, and mimic shiner (listed in order of numerical abundance). Table 8 summarizes fishery indices used to help describe the lake's fish community. White sucker, largemouth bass, and banded killifish comprised the largest portion of the total catch numerically, 37%, 21%, and 13%, respectively. White sucker and largemouth bass fry caught in seine hauls inflated numbers for these species. Brown bullhead, bluegill, and pumpkinseed/rock bass comprised the largest portion of the fyke net catch numerically, 55%, 23%, and 6%, respectively. Brown bullhead comprised the largest proportion of the catch in terms of biomass (estimated). No 203 mm (8 in) bluegill were observed. No species or age class provided large enough samples for growth indices to be calculated. Limited age data suggest that, in general, Bass Lake offers a below average to poor fishery with growth of predatory gamefish lower than average. Specifically, only three age classes of northern pike were collected (five fish), all of which had smaller length at age than State average. Largemouth bass and rock bass exhibited larger length at age than State average, although the differences were not statistically significant.

Similar to School Lake, the nearshore habitat of Bass Lake could be improved with increased frequency and abundance of large woody debris or whole trees. Bullhead removal may also benefit the fisheries. Further surveys are recommended to better evaluate growth and survival of gamefish species. Moderate attention to this lake has greater potential for improving gamefish fishery quality than on adjacent School Lake.

Table 8. Summary of community indices for Bass Lake, Leelanau County (2003).

Lake Community Indices	Statistic	Interpretation
Number of Species Observed	11	
Bluegill Size Score	1	Very Poor
Bluegill Growth Index	NA	Insufficient Data
Percent Bluegill/Pumpkinseed	28.8%	Acceptable
Presence of 203 mm (8 in) Bluegill	None	Unsatisfactory
Percent Predators	9%	Unsatisfactory
Largemouth Bass Growth Index	Not Determined	Insufficient Data

Seven species were observed in the survey performed in 1979. The only species observed in 1979 but not in 2003 was yellow bullhead. Yellow bullhead may have been out-competed by brown bullhead; however, it is also possible that yellow bullhead are still present in small numbers. All other species observed in 1979 were also seen in 2003. Species observed in 2003 but not in any previous surveys listed in Kelly and Price (1979) are largemouth bass, pumpkinseed, yellow perch, and mimic shiner. Northern pike were not present in either Bass Lake or School Lake until 1959 when the MDNR stocked 229 adult fish. In 1979 they were cited as “well established”. They are in fact still present and naturally reproducing with limited recruitment; however, growth is poor in both lakes.

Shell Lake

Shell Lake is 41.3 ha (102 ac) bordered on the west side by steep contours of upland hardwoods and by relatively flat, mixed hardwood conifer stands to the south and east. Motors are prohibited in this lake, and access is generally limited to canoes and small boats. Shell Lake has a shallow, muck bottom, with average depth of approximately 2.4 m (8 ft). The only variation in lake bottom topography is a series of three connected deeper channels running perpendicular to the west shoreline of the lake with depths of nearly 4.0 m (13 ft). The shoreline has moderate complexity and is dominated by bulrush, sedge, and cattail colonies. Most of the shoreline is defined with gentle slopes to the water’s edge. The only exception is the western shoreline, which is more abrupt. Large woody debris is widely distributed and moderate in abundance. Beaver activity contributes significantly to the amount and distribution of woody debris in this lake. Sparse macrophyte cover occupies much of the lake bottom with composition comprised largely of muskgrass, pondweed, coontail, and water-lily. A small cove at the north end of the lake exhibits markedly higher densities of pond lilies and pondweed. Water quality parameters measured on two occasions in early June revealed nothing remarkable. During the sampling periods the lake was mixing, and dissolved oxygen was supersaturated during one sampling period on June 17. It is not known whether this lake has a history of winterkill.

Fishery surveys were performed in June 2003 using fyke nets, seines, and minnow traps. We sampled six net nights (three fyke nets for two nights), and 16 minnow traps were fished for one night. A total of six seine hauls were conducted in several locations where the shoreline was wadeable (Figure 9). A total of 10 species were collected: bluntnose minnow, bluegill, banded killifish, largemouth bass, mimic shiner, Johnny darter, pumpkinseed, sand shiner, Iowa darter, and yellow perch (listed in order of numerical abundance). Table 9 summarizes fishery indices used to help describe the lake's fish community. Bluntnose minnow, bluegill, and banded killifish comprised the largest portion of the total catch numerically, 51%, 29%, and 6%, respectively. Fish community characteristics are markedly different from other lakes within the Shalda Creek watershed. Most notable are the absence of bullhead and the growth of bluegill. Bluegill comprised the largest portion of the fyke net catch numerically and likely comprises the bulk of the gamefish biomass in the lake. Growth of both bluegill and pumpkinseed is significantly greater than State average. Four age classes of largemouth bass were aged, though only two provided large enough samples to calculate the growth index presented in Table 9. Three of four age classes had average length at age greater than State average. Another notable characteristic of the fish community was the abundance of cyprinids. On one occasion a seine haul was shortened in order to avoid extremely large schools of minnows and minimize unnecessary mortality. Schools of cyprinids in excess of 1,000 were not uncommon. Furthermore, as found in 1979, Shell Lake was the only lake surveyed in 2003 in the Shalda Creek watershed in which darter species were observed (most notably Iowa darter).



Seine Haul on Shell Lake

It is likely that bluegill populations are limiting early growth and recruitment of largemouth bass. An important aspect of largemouth bass population dynamics is the ontogenetic shift in diet from invertebrates to fish within the first year of life. This shift can be affected by factors including environmental conditions and competitive processes of bluegill and other species that utilize invertebrates as a food source. Further, survivorship of young-of-year bass is strongly size dependent, therefore the timing of a shift to piscivory for largemouth bass can have an effect on population dynamics (Olson 1996). It is unknown whether many adult bass are removed from the system by anglers. Avian predators may also remove some of the older year classes, although this has not been directly evaluated. The abundant cyprinid forage is significant and likely reduces bass predation pressure on bluegill, thereby increasing competitive interactions between bluegill and largemouth bass. Further evaluation of largemouth bass growth and abundance will give insight to bass and bluegill management options. Shell Lake should also be monitored in

conjunction with School, Bass, and Narada if bullhead removal and habitat improvements are considered in those lakes.

Table 9. Summary of community indices for Shell Lake, Leelanau County (2003).

Lake Community Indices	Statistic	Interpretation
Number of Species Observed	10	
Bluegill Size Score	2	Poor
Bluegill Growth Index	+1.6	Superior
Percent Bluegill/Pumpkinseed	88.9%	Acceptable
Presence of 203 mm (8 in) Bluegill	Yes (1)	Relatively Good Population
Percent Predators	11%	Unsatisfactory
Largemouth Bass Growth Index	-0.45	Below State Average

Kelly and Price (1979) observed 10 species in their survey; however, their species table only listed nine species. White sucker and smallmouth bass were observed in 1979 but not in 2003. White sucker are very common in the Shalda Creek watershed, and it is likely this species persists in Shell Lake today. Smallmouth bass may not be present currently as they are susceptible to competition by largemouth bass and bluegill. Additionally, the 1979 survey yielded no estimates of abundance; therefore it is not possible to determine whether smallmouth bass were observed in large numbers. All other species observed in 1979 were also seen in 2003. Species observed in 2003 but not in any previous surveys listed in Kelly and Price (1979) included mimic shiner, sand shiner, and Johnny darter.

Crystal River Watershed

The Crystal River watershed includes Big and Little Glen Lakes, Tucker Lake, Fischer Lake, Hatlams Creek, and Day Mill Pond. The only waterbodies entirely within SLBE, and therefore the only systems surveyed in 2003, are Tucker Lake and Day Mill Pond. Day Mill Pond was referenced in 1979 as isolated from Little Glen Lake; however, a small culvert running under Highway 109 provides limited connection at times between the waterbodies. Furthermore, northern pike have been observed in past surveys in Day Mill Pond and likely were the result of spawning runs originating from Little Glen Lake.

The Crystal River is a large stream emerging from Fischer Lake and is situated on lake terraces and beach ridges. The river drains nearly level to gently sloping sandy soils and nearly level poorly drained mucky soils (Soil Survey of Leelanau County, Michigan 1973). These soils contain layers of gravel and coarse sand, which are evident in the streambed. Also abundant are slow backwaters with muck substrates often covered with muskgrass and water milfoil (*Myriophyllum* sp.) (Kelly and Price 1979). From its origin at Fischer Lake to its mouth is approximately 10 km (6.2 mi), of which about 4.2 km (2.6 mi) is within SLBE. A small weir and water control structure is situated approximately 0.4 km (0.3 mi) downstream of Fischer Lake. This weir limits the migration of small fish species including smelt, cyprinids, and sea lamprey; however, anadromous salmonids can pass without difficulty. Discharge measured on August 5, 1998, was 0.9 m^3/s (32 ft^3/s), although this rate can vary greatly depending on the position of the sluice gate in the dam. The discharge from Fisher and Glen Lakes into the Crystal River is dependent upon a court-approved algorithm, which is determined by a court-approved Technical Committee,

working in conjunction with the Glen Lake Water Level Committee. Thirty cfs is the minimum flow, based upon the available evidence that is necessary to prevent damage to the river. We suspect that relatively little groundwater enters this stream and that the stream therefore lacks a temperature buffer in the extremes of summer and winter. Average daily temperatures in July 2001, 2002, and 2003 were 23.0, 24.8, and 22.6 ^{o}C, respectively (Figure 10).

We did not conduct fishery surveys on the Crystal River in 2003. As noted in Kelly and Price (1979), USFWS has surveyed this river on almost an annual basis since 1960 as part of their sea lamprey control program. In their multiple surveys they have observed 20 species of fish, including a small number of blackside darter. The MDNR reported eight species in 1965. In 1998, the Grand Traverse Band of Ottawa and Chippewa Indians Natural Resources Department (GTB-NRD) conducted an electrofishing survey at three locations (Figure 11). Including the species observed by Kelly and Price (1979), 31 species have been observed in surveys since the 1960s (Appendix B). Data presented in Kelly and Price (1979) do not reflect relative abundance of species captured. The only available data on relative abundance are those collected by GTB-NRD in 1998. In that survey, the five most abundant species were rock bass, Johnny darter, horny head chub, central mudminnow, and smallmouth bass.

In comparison to streams of similar width in northern Wisconsin that empty into Lake Michigan, the Crystal River had an IBI score of 65 and is considered comparable to the best situations with minimal human disturbance. All regionally expected species for habitat and stream size, including the most intolerant forms, are present with a full array of age and size classes; the river exhibits a balanced trophic structure (Lyons 1992).

The Crystal River is classified by the MDNR as a type 3 stream, which designates it as a trout stream open all year to all species. As in Shalda Creek, the only significant sport fisheries provided by the Crystal River are the product of anadromous salmonid runs in spring and fall. Migrations of smelt have also been known to occur and provide a limited fishery in certain years. Multiple steelhead recruitment surveys have been conducted by the Grand Traverse Band in the Crystal River and have not produced any indication of recruitment to date. Juvenile coho salmon have not been observed in any recruitment surveys, and at the time of the surveys juvenile Chinook salmon would have left the stream. Additionally, the most abundant species found during our surveys were generally pisciverous (fish-eating) warm/cool water species including smallmouth bass, rock bass, largemouth bass, northern pike, pumpkinseed, and yellow perch. This species composition is not conducive to steelhead trout recruitment, and it is likely that water temperature regimes significantly limit salmonid production in this system. No management recommendations are indicated.

Tucker Lake

Tucker Lake is 6.9 ha (17.3 ac) largely surrounded by relatively level contours with cover types of lowland conifers and cattail marsh. Motors are prohibited in this lake, and access is generally limited to canoes and small boats. Tucker Lake is an upstream basin connected to Fischer Lake by a short (1000 m [3300 ft]) channel with very little gradient. The uniform shallow basin has a soft organic bottom, with average depth of approximately 2.7 m (9 ft) and a maximum depth of 3.7 m (12 ft). The shoreline has moderate complexity with an abrupt bank and abundant large woody debris in and adjacent to the water. Aquatic plants are well established and flourishing with pondweed, muskgrass, and pond-lily in abundance. Water quality parameters measured on June 4 and 25 revealed nothing remarkable. Surface temperatures ranged from 17.3-18.4 °C and

21.3-25.3 °C, respectively. Dissolved oxygen profiles from surface to bottom ranged from 105% to 85% (9.6 to 8.0 ppm) on June 4, 2003, and 124% to 14% (10.0 to 1.3 ppm) on June 25, 2003.

Fishery surveys were performed in June and November 2003 using fyke nets, gillnets, and minnow traps. Seines were not used due to the soft muck bottom and the abundance of woody debris. We sampled 10 net nights (three fyke nets for three nights, and one gillnet for one night), and 15 minnow traps were fished for one night (Figure 12). A total of 10 species were collected: bluegill, pumpkinseed, yellow perch, brown bullhead, largemouth bass, northern pike, rock bass, yellow bullhead, central mudminnow, and Iowa darter (listed in order of numerical abundance). Table 10 summarizes fishery indices used to help describe the lake's fish community. Bluegill, pumpkinseed, and brown bullhead comprised the largest portion of the catch numerically, 64%, 11%, and 9%, respectively. Growth of bluegill is slightly above State average; however, the community lacks a large component of older, larger fish (>age 4 and >6 in). Three age classes of largemouth bass were aged, though only two provided large enough samples to calculate the growth index presented in Table 10. Growth of age 3 and 4 largemouth bass was significantly greater than State average. No cyprinids were captured or observed visually during this survey. Young centrachids are the principal forage in this lake. Though insufficient data were collected to calculate a growth index for northern pike, average length at age is below State average. Although insufficient data were available to calculate a growth index for rock bass, growth appeared to be above State average.

In general, Tucker Lake likely provides an average fishery. It is easily accessible, but not very large and can likely support only minimal fishing pressure. Fish habitat qualities of this lake are above average. Significant macrophyte growth in this lake may limit predation success of bass and northern pike; however, bass growth data do not support this pattern. Macrophyte densities should be monitored to prevent habitat "choking". This lake could be a candidate for a staggered year bullhead removal effort with subsequent periodic monitoring of gamefish growth and abundance.

Table 10. Summary of community indices for Tucker Lake, Benzie County (2003).

Lake Community Indices	Statistic	Interpretation
Number of Species Observed	10	
Bluegill Size Score	1	Very Poor
Bluegill Growth Index	+0.27	Average
Percent Bluegill/Pumpkinseed	76.5%	Unsatisfactory
Presence of 203 mm (8 in) Bluegill	None	Unsatisfactory
Percent Predators	8.6%	Unsatisfactory
Largemouth Bass Growth Index	+2.5	Above State Average

Kelly and Price (1979) observed six species in their survey, but no minnows. All species observed in 1979 were again observed in 2003. Large numbers of sunfish likely provide forage for northern pike, largemouth bass, and perch. Darters were also observed but not collected. Species observed in 2003 but not in any previous surveys listed in Kelly and Price (1979) were central mudminnow, brown bullhead, yellow bullhead, and Iowa darter.

In 2003 we captured nine painted turtles and one large snapping turtle age >15 years. Several large beaver lodges are present on this lake, and at least one is active. A significant amount of the woody debris in this lake is provided by beaver activity.

A dump site was situated in the watershed of Tucker Lake. Due to its history, Tucker Lake was selected to be monitored for contaminants in fish. Ten northern pike and ten brown bullhead were collected and tested for mercury and chlorinated organics. The Michigan Department of Environmental Quality (MDEQ) reported low concentrations of mercury in the bullhead, and all other constituents were below quantification levels.

Day Mill Pond

Day Mill Pond is a small (2.3 ha [5.7 ac]), shallow pond situated northwest of Little Glen Lake and near the base of the dune climb. Average depth is approximately 1.2 m (3.9 ft). There is a connection to Little Glen Lake via a culvert under Highway 109. Day Mill Pond was likely once a backwater of Little Glen Lake before the construction of Highway 109. The bottom is largely organic muck with luxuriant growth of muskgrass, pondweed, and water-lily.

A fishery survey was performed on June 23, 2003, using a backpack electrofisher deployed from a 5 m (16 ft) canoe. A total of 8.1 min of shock time was recorded. The only species collected was central mudminnow. Figure 13 summarizes species caught, effort, and electrofishing courses.

Kelly and Price (1979) observed one species in their survey; one northern pike was captured. Northern pike were not observed in 2003; however, large numbers of central mudminnow were captured. The presence of a small northern pike in 1979 suggests there is periodically a connection to Little Glen Lake passable to fishes and that Day Mill Pond could provide spawning habitat for northern pike if fish passage were improved.

Otter Creek Watershed

Otter Creek

Otter Creek is a first order stream flowing northwest in Benzie County. Deer, Bass, and Otter Lakes collectively supply Otter Creek as they all share surface water connections. These lakes are also supported substantially by groundwater. Average discharge of Otter Creek is approximately 0.5 m^3/s (18 ft^3/s) near the mouth. A short section below the culverts on Aral Road exhibits sand and gravel substrates with small pools scoured beneath piles of large woody debris from beaver activity. The mouth of Otter Creek regularly shifts position due to longshore drifting of sand induced by wave action. Occasionally the stream is impounded by sand bars created during storms. Prior to the installation of the existing twin culverts at Aral Road, severe storm events resulting in damming at the mouth caused water levels to rise above the road crossing and subsequently wash out the road crossing when the impounding sands were breached (S. Yancho, pers. comm.). The original culvert was probably not large enough to accommodate a large and sudden discharge resulting from the release of impounded waters. The existing culverts also limit flow into Lake Michigan to some extent and cause limited ponding above the road, particularly when the culverts are partially obstructed through beaver activity.

Most of the middle section of the stream is an open marshy pond with sand and muck substrates and large colonies of rushes, sedges, cattails, and lilies. Approximately 1.5 km (0.9 mi) upstream from the road crossing, the stream channel narrows significantly and deeper pools are less frequent. Willow and tag alder dominate much of the shoreline. Beaver activity in Otter Creek is frequent. Several partial dams and active lodges were observed during the fishery survey. Large submerged caches of woody debris were observed in various locations within the marsh/pond and upstream. Considerable groundwater flow influences this stream and acts as a temperature buffer in the extremes of summer and winter. Approximately 1400 m (4620 ft) from the mouth a short but significant tributary discharging from Aral springs flows directly into Otter Creek, with estimated flows greater than 0.1 m^3/s (3.5 ft^3/s). Below this confluence multiple (at least five) additional feeder streams flow into the marsh/pond section from adjacent wetlands and cedar swamps and also contribute significantly to the discharge of Otter Creek (Figure 14). Dozens of groundwater upwelling sites have also been observed in (or very near) the mainstem of Otter Creek, some of which emerge through caches of woody debris.



Groundwater Upwelling Otter Creek

The only other portion of Otter Creek that contains gravel substrates in amounts that are useable by salmonids for spawning is an upper section located approximately 300 m (990 ft) downstream from the outfall of Otter Lake. With the exception of the lower portion at the Aral Road crossing near the mouth, this upper section is the only area where Pacific salmonids have been observed spawning (Figure 14).

Continuous temperature data were collected in 1998. The generally accepted upper level of preferred temperature for salmonids is approximately 22 $^{\circ}C$. Average daily temperature from June through July was 18.7 $^{\circ}C$. Average daily temperatures never exceeded 22 $^{\circ}C$ in Otter Creek (Figure 15). Water quality data collected on July 2, 2003, yielded nothing remarkable, except that dissolved oxygen levels were somewhat low at 53% saturation and 5 ppm. These data are comparable to levels seen near the many springs that feed Otter Creek (see Aral Springs section). Water temperature at the time of sampling was 16 $^{\circ}C$, but time of day was not noted. Dissolved oxygen should be checked during winter months to investigate the potential for oxygen limiting conditions.

A backpack electrofisher was used intermittently to sample a total of approximately 2000 m (6600 ft) of stream channel from the mouth up to approximately 1000 m (3300 ft) downstream of Otter Lake in July 2003. Locations sampled were principally focused on areas where instream cover was abundant; specifically, beaver caches of woody debris, beds of vegetation, and

stretches of shoreline where the bank was undercut (Figure 14). Total shock time was 41.2 min. Additionally, one small mesh fyke net 0.61 x 0.91 m (2 x 3 ft) was fished for one night approximately 10 m upstream from the culverts crossing Aral Road. A total of 18 species were observed, including 32 brook trout, of which 13 were large enough to sample scales for aging. A full list of species observed in order of abundance is presented in Figure 14. Nearly all of the observed brook trout were captured below the confluence with the outflow of Aral Springs. Numerically, bluegill comprised the largest percent of the catch (26%), followed by bluntnose minnow (17%), rock bass (12%), and brook trout (9%). No stocking occurs in Otter Creek, and natural reproduction of brook trout is evident in addition to other Pacific salmonids. Five age classes of brook trout were captured from age 1 to age 5; however, only one age class (age 3) yielded a large enough sample to calculate a growth index. Growth of age 3 brook trout is significantly lower (-1.3) than State average. For the remaining age classes, length at age was also significantly less than State average. Steelhead, brown trout, and Pacific salmon are known to occupy Otter Creek seasonally and have been observed in the uppermost reaches of the watershed, including Bass Lake and Deer Lake. It is likely that limited recruitment of these species occurs in most years.

In comparison to streams of similar width in northern Wisconsin that empty into Lake Michigan, Otter Creek had an IBI score of 65 and would be considered comparable to the best situations with minimal human disturbance. All regionally expected species for habitat and stream size, including the most intolerant forms, are present with a full array of age and size classes and a balanced trophic structure (Lyons 1992). However, due to its temperature regime and the presence of salmonids, particularly brook trout, Otter Creek does not entirely fit within the category of “warmwater” streams. Conversely, its fish community composition reflects less of a “traditional” trout stream where species composition is typically limited to salmonid and sculpin species. Considering this intermediate classification, Otter Creek has the potential for a productive brook trout fishery if managed appropriately. The forage base is exceptional. Otter Creek is classified by the MDNR as a type 1 stream, which designates it as a trout stream open to fishing from the last Saturday in April to September 30 with size limits on brook and brown trout of 203 mm (8 in) and 254 mm (10 in) for rainbow trout and Pacific salmon. Fishery quality to the public would improve if the stream designation were changed to type 4 to allow greater access to Pacific salmon and steelhead fisheries. This change would have no significant impact on brook trout or lake populations of steelhead, Chinook, or coho. In fact, this change in regulatory classification may even have a positive effect on brook trout by reducing numbers of Pacific salmonids competing for space and resources in this stream. Type 4 streams are open all year for Pacific salmon and steelhead, and from the last Saturday in April to September 30 for brook and brown trout; size limits are 203 mm (8 in) for brook trout and 254 mm (10 in) for all other salmonids except lake trout (610 mm [24 in]).

As indicated above, fishery surveys have documented a naturally reproducing brook trout population; however, it is not known conclusively whether this population contains any element migrating to and/or from Lake Michigan (anadromy). It has been shown that given the presence of groundwater upwellings, brook trout will spawn over woody debris, sand, and sandy silt substrates (Powers 1980; Curry and Noakes 1995). Gravel substrates are also known to be used by spawning brook trout in the presence or absence of upwellings. All of these habitat features exist in Otter Creek. The stream is considered very unique, in that it appears that brook trout

persist despite its direct migratory access to anadromous Pacific salmonids from Lake Michigan which typically out-compete brook trout in other systems. Given favorable temperatures, an exceptional forage base, and habitat characteristics coupled with the abundance of brook trout, it is recommended that further investigation be conducted to evaluate the existing brook trout population with respect to population size and health, migration patterns (anadromy), and genetics. Once evaluated, this stream appears to be potentially well suited for a lake run (coaster) brook trout restoration effort. USFWS and Tribes elsewhere have strongly supported the initiative to restore coaster brook trout populations in historic Great Lakes habitats. Currently, research is planned to be conducted by Grand Traverse Band Natural Resources in 2007-2009 to evaluate the population structure, migratory patterns, and genetic composition of brook trout in the Otter Creek system.

Additionally, improvement of the road stream crossing at Aral Road would alleviate problems with wash-outs, if flow is impeded at the mouth, and also help in returning this stream to its natural flow regime, which would help improve migratory fish passage. Timber bridges or box culverts are typically used to remedy inadequate discharge capacities and also provide a natural bottom composition under the road crossing. This recommendation is currently being explored through a collaborative grant application to the Targeted Watershed Grants Program through the EPA by the Grand Traverse Band, Conservation Resource Alliance, and the NPS.

As cited in Kelly and Price (1979), USFWS has periodically surveyed this stream since 1967 as part of their sea lamprey control program. These surveys primarily focus on detecting sea lamprey with secondary emphasis on species composition. After multiple surveys, they have observed 21 species of fish. No sea lamprey have been detected. Including the species observed by Kelly and Price (1979), the USFWS, and the 2003 NPS survey, a total of 25 species have been observed in surveys since the 1960s (Appendix C). Species observed by USFWS or Kelly and Price (1979) but not observed in 2003 were Johnny darter, spot-tail shiner, and blacknose shiner. Blacknose shiner were observed in Otter Lake and are likely in Otter Creek. Johnny darter and spot-tail shiner are common in the region and likely persist in Otter Creek as well. Species observed in 2003 but not in any other previous surveys listed in Kelly and Price (1979) were bluegill and longnose dace. In 1979 the electrofishing survey was limited to the wadeable section below the Aral Road bridge, and minnow traps were used to sample the upper portion. All species observed in 1979, with the exception of one central mudminnow, were found below the bridge. This short section of stream was cited as containing a very diverse assemblage of fish. As noted above, the 2003 electrofishing surveys occurred throughout most of the stream basin. Many species of cyprinids were observed upstream, including creek chub, hornyhead chub, common shiner, sand shiner, and bluntnose minnow. Other species observed upstream included bluegill, pumpkinseed, yellow perch, rock bass, white sucker, smallmouth bass, and brook trout. The 2003 survey indicates that a very diverse fish assemblage exists in the upstream marsh-pond habitat as well.

Aral Springs

Aral Springs (as they are known locally) are a collection of at least 13 springs emerging from a cedar swamp approximately 1400 m (4620 ft) upstream from the mouth of Otter Creek (Figure 16). The springs emerge from historic marl pits and form small overland and subsurface rivulets feeding Otter Creek with groundwater. The landscape and soil features, coupled with the

emergence of these springs, results in a rare form of wetland classified as calcareous fen. These types of wetlands have been considered some of the rarest types in North America. They typically contain plant communities adapted to the calcium and magnesium bicarbonate precipitates commonly associated with these wetlands. These precipitates are the result of such minerals in high concentration within the groundwater supplying these springs (Curtis 1971). Trout streams are generally associated with these wetlands as they benefit from the temperature moderation offered by the discharging groundwater (Eggers and Reed 1997). Water quality data collected annually from 1999 to 2003 from seven of the main springs yielded average temperatures of 9.02 °C and dissolved oxygen levels of 49.14% saturation and 5.59 ppm. These data exhibit only slight temporal fluctuations, as would be expected from groundwater discharge. Additional water chemistry analyses are available from the water resources program at SLBE. Substrates within the rivulets are predominantly sand and marl with fine particulate organic matter (muck) along stream margins. Aquatic vegetation observed during the fishery survey included muskgrass, water parsnip *(Sium suave)*, and elodea.


Groundwater spring Otter Creek

A fishery survey was performed on June 8, 2004, using a backpack electrofisher. A total of four rivulets and four spring pots were sampled over a total shock time of 12 min. Five species were observed: brook trout, central mudminnow, mottled sculpin, brook stickleback, and yellow perch (listed in order of numerical abundance). The largest brook trout captured was 124 mm (4.9 in) and the balance were young-of-year trout, indicating the presence of natural reproduction and confirming the value of this area in terms of nursery habitat and thermal refuge for young brook trout. As indicated in the Otter Creek evaluation, most of the adult brook trout sampled in the stream were observed near the confluence of Aral Springs discharge and Otter Creek. Kelly and Price did not survey Aral Springs in 1979 nor did they reference the groundwater contribution of this area to Otter Creek.

Otter Lake

Otter Lake is a 26 ha (64 ac) basin situated approximately 1.25 km (0.78 mi) upstream from the mouth of Otter Creek. Its drainage to the west is principally upland hardwoods. Cedar swamps border the northern portion of the lake where Otter Creek begins. Motors are prohibited in this lake, and access is generally limited to canoes and medium-sized boats. Otter Lake has a convoluted shallow basin with a soft marl bottom and averages approximately 3.7 m (12 ft) in depth with a maximum depth of 6.4 m (21 ft). Nearshore areas along the northern and eastern shoreline have bands of sand and gravel substrates and also likely produce limited groundwater. A large spring located offshore in the northeast section of the lake supplies groundwater to the system. Discharge of this spring was not calculated; however, it is significant as the spring vent

is approximately 6 m (20 ft) in diameter. The shoreline has moderate complexity with an abrupt bank and abundant large woody debris in and adjacent to the water, particularly on the western shoreline. Macrophytes are average in abundance and are distributed in patches throughout the lake. Beds are comprised chiefly of pondweed, muskgrass, and coontail. Shoreline macrophytes include bulrush, sedges, and cattail.

Fishery surveys were performed in October 2003 using fyke nets, gillnets, seines, and minnow traps. We sampled 18 net nights (four fyke nets for three nights and two gillnets for three nights), and 16 minnow traps were fished for one night. Only one seine haul was conducted as most of the shoreline was too deep nearshore or too soft to wade safely (Figure 17). A total of 16 species were collected: bluegill, bluntnose minnow, pumpkinseed, rock bass, blacknose shiner, largemouth bass, yellow perch, Iowa darter, common shiner, coho salmon, smallmouth bass, black crappie, northern pike, white sucker, brown bullhead, and banded killifish (listed in order of numerical abundance). Table 11 summarizes fishery indices used to help describe the lake's fish community. Bluegill, bluntnose minnow, and pumpkinseed comprised the largest portion of the catch numerically, 60%, 13%, and 8%, respectively. The survey reflects a significant forage base in this lake. Most notable are large numbers of stock size age 0, 1, and 2 bluegill. Bluegill comprised the largest portion of the fyke net catch numerically and likely comprise the bulk of the gamefish biomass in the lake. No 203 mm (8 in) bluegill were observed during the survey. Unfortunately, only one age class of bluegill provided a large enough sample to calculate a growth index. Growth of age 3 bluegill was below State average. Length at age for the remaining two age classes for which scales were collected were also lower than State average. Only one age class of largemouth bass provided a large enough sample to calculate the growth index presented in Table 11. Growth of bass in general appears to be significantly below State average. No other species from which ages were taken had large enough samples to calculate a growth index. These include northern pike, pumpkinseed, rock bass, yellow perch, black crappie, and smallmouth bass. It should be noted that length at age for most of these species was below State average. Another notable characteristic of the forage base is the large complement of cyprinids. Although seining did not produce many fish, it is important to note that minnow traps caught large numbers of bluntnose minnow and juvenile bluegill. This was by far the best performance of minnow traps as compared to results from all other lakes surveyed in 2003.

Table 11. Summary of community indices for Otter Lake, Benzie County (2003).

Lake Community Indices	Statistic	Interpretation
Number of Species Observed	16	
Bluegill Size Score	1	Very Poor
Bluegill Growth Index	-0.7	Poor (based on only one age class)
Percent Bluegill/Pumpkinseed	44.0%	Satisfactory
Presence of 203 mm (8 in) Bluegill	None	Unsatisfactory
Percent Predators	8.0%	Unsatisfactory
Largemouth Bass Growth Index	-1.1	Poor (based on only one age class)

Similar to other lakes in SLBE it is likely that bluegill populations are limiting early growth and recruitment of largemouth and smallmouth bass, and possibly other predators. It is not known how many predators are removed from the system by anglers; however, anecdotal information suggests this lake receives significantly higher angling pressure than most other lakes surveyed in 2003. The abundant cyprinid forage may reduce predation pressure on bluegill, thereby increasing competitive interactions with predators. Control of overabundant bluegill could be accomplished through a judicious stocking of 1,500-2,000 spring fingerling or 600-700 fall fingerling walleye, if Park and NPS policies allow for such an effort. Further surveys are recommended to better evaluate growth and survival of gamefish species and provide management options. Monitoring of exotic species abundance should continue to evaluate impacts on the fish communities. Options to remove or reduce populations of non-native species should also be explored. Zebra mussels have been in Otter Lake since 2001, but do not yet appear to be present in significant numbers. Rusty crayfish were observed in 2003. This is the first known observation of this species in this lake. The relatively recent infestations of these species also warrant continued monitoring.

Beaver activity is prevalent in the lake. Efforts to control such activity are evident where Otter Creek flows out of the lake. The beaver deceiver installed at this site is only functioning partially. Aesthetically, this construction is less than acceptable. A significant amount of the woody debris in this lake is provided through the actions of beaver. The original purposes for discouraging beaver activity in this drainage may merit review and discussion.

Kelly and Price (1979) observed nine species in Otter Lake. They noted a dense population of minnows (creek chubs and common shiners) at the north end of the lake. All species observed in 1979 were also observed in 2003 with the exception of creek chubs and sand shiners. Both of these species were found in Otter Creek during the 2003 survey. Given this and the fact that we could not seine Otter Lake, it is quite possible these species still persist in the lake. Species observed in 2003 but not in 1979 include coho salmon, northern pike, blacknose shiner, brown bullhead, banded killifish, bluegill, pumpkinseed, smallmouth bass, and Iowa darter. Kelly and Price employed only gillnets and seines in 1979, and it is likely that seining was not very productive due to the shoreline and substrates. Gillnets employed in 2003 did not perform very well and captured mostly the same species that Kelly and Price captured. Fyke nets were the most productive gear in the 2003 survey, particularly for centrarchids. The productivity of fyke nets may in part explain the substantially larger species composition reported in 2003.

Upper Otter Creek

A short (375 m [1230 ft]) stream locally known as Upper Otter Creek connects Otter and Bass Lakes. It flows through a narrow low basin between the lakes dominated by northern white cedar. Substrates are largely muck, sand, and marl accentuated with small pockets of gravel in areas where scour is prevalent. Gradient is slight, and some impoundment occurs at the road crossing despite the employment of a beaver activity control device. The device was operating correctly during our survey. Discharge was not measured; however, it is clear that a significant proportion of the downstream flow through Otter Creek discharging from Otter Lake is contributed from Bass Lake.

A fishery survey was conducted on July 26, 2004, using a backpack electrofisher deployed for a total of 16.8 min. The section downstream of the Trails End road crossing was sampled from Otter Lake to the bridge (Figure 18). Thirteen species were observed: bluegill, pumpkinseed, yellow perch, bluntnose minnow, creek chub, central mudminnow, rock bass, Iowa darter, common shiner, blacknose shiner, white sucker, brook stickleback, and largemouth bass (listed in order of numerical abundance). As cited in Kelly and Price (1979), the USFWS has surveyed this stream on almost an annual basis since 1960 as part of their sea lamprey control program. In multiple surveys they have observed nine species of fish, all of which were observed in 2004 with the exception of brook trout and coho salmon. Because the survey occurred in July, instream water temperatures were inhospitable for salmonid species. Water temperature at the time of the survey was 25 $^{\circ}$C. Species observed in 2004 that were not reported in Kelly and Price (1979) were bluegill, yellow perch, bluntnose minnow, Iowa darter, blacknose shiner, white sucker, and brook stickleback. Due to the relatively short distance between Otter and Bass Lakes, it is likely that fish community composition in Upper Otter Creek varies temporally, and at least during some periods contains the same species composition as both lakes. Beaver activity appears to be an issue at the road crossing as evidenced by the control device. Fish passage may be impeded to a limited degree at times by the device, as it is periodically congested with debris. Northern pike may use this stream for spawning; therefore, it is important to keep the beaver activity control device clear of debris, particularly during early spring.

Bass Lake

Bass Lake is a 67 ha (166 ac) basin situated approximately 350 m (1148 ft) upstream from Otter Lake. Basin structure and drainage are similar to Otter Lake, with cedar swamp to the north and south and upland hardwoods on the western shoreline. Motors are prohibited in this lake, and access is generally limited to canoes and medium-sized boats. Bottom contours are convoluted with a slightly deeper basin than Otter Lake. Average depth is approximately 4.6 m (15 ft), and maximum depth is 7.9 m (26 ft). Bottom substrates are soft marl and organic muck. Much of the lake's water is likely input through groundwater along the southern shore and from adjacent Deer Lake. The shoreline is similar to that of Otter Lake with moderate complexity, an abrupt bank, sharp drop-offs, and abundant large woody debris both in and adjacent to the water. Macrophytes are average in abundance and are distributed in patches throughout the lake with highest densities in cove areas. Beds are comprised chiefly of pondweed, muskgrass, water-lily, and coontail. Shoreline macrophytes include bulrush, sedges, and cattail. Water quality data collected in October 2003 yielded nothing remarkable. Slight chemical changes may be occurring; however, continued sampling to monitor these trends was cited in the 2003 water quality report by Murphy (2003).

Fishery surveys were performed in October 2003 using fyke nets, gillnets, and minnow traps. We sampled 12 net nights (four fyke nets for two nights and two gillnets for two nights), and 16 minnow traps were fished for one night (Figure 19). Seine hauls were not conducted due to the soft muck bottom, sharp drop-offs, and abundance of woody debris. Thirteen species were collected: bluegill, rock bass, pumpkinseed, largemouth bass, yellow perch, bluntnose minnow, northern pike, coho salmon, black crappie, chinook salmon, central mudminnow, Johnny darter, and white sucker (listed in order of numerical abundance). Table 12 summarizes fishery indices used to help describe the lake's fish community. Bluegill, rock bass, and pumpkinseed comprised the largest portion of the catch numerically, 73%, 7%, and 6%, respectively. The survey reflects

adequate forage in this lake. The bluegill sample was dominated by stock size fish age 0, 1, and 2. Bluegill comprised the largest portion of the fyke net catch numerically and likely comprised the bulk of the gamefish biomass in the lake. As in Otter Lake and others there was a noticeable absence of desirable-sized bluegill (203 mm [8 in]). Unfortunately, growth of adult bluegill or largemouth bass was not assessed due to insufficient numbers per age class. Six age classes of largemouth bass were captured. We were unable to calculate growth indices for any species due to insufficient data. Species aged include northern pike, pumpkinseed, rock bass, yellow perch, and black crappie. It should be noted that length at age for most of these species was below State average. As noted above, effort was 12 net nights, which meets and/or exceeds conditions in the protocol. We considered fishing an additional night with six nets, but concluded that catch would not likely increase appreciably.

It is difficult to interpret the fish community in this lake due to the apparent lack of representative data. It is not known how successful anglers are on this lake; however, anecdotal information suggests that this lake receives higher angling pressure than most other lakes surveyed in 2003 and that success is variable. Multiple age classes of largemouth bass and one large (783 mm [30 in]) northern pike were observed during the 2003 survey. The largest sample of "catchable" fish was yellow perch. This lake likely provides a mediocre fishery. Bass Lake may be a candidate for a walleye plant; however, evaluation of the stocking effort in Otter Lake (if it is approved through NPS policy and implemented) should occur before such a prescription is considered for Bass Lake. Further surveys are recommended to better evaluate growth and survival of gamefish species and provide management options. Monitoring of exotic species abundance should continue to evaluate impacts on the fish communities. Zebra mussels have been in Bass Lake since 2001, but do not appear to be present in significant numbers yet. Rusty crayfish were found in Otter Lake, but not in Bass Lake. The relatively recent infestations of these species in these basins warrant continued monitoring and, if possible, efforts to control or reduce the populations.

Table 12. Summary of community indices for Bass Lake, Benzie County (2003).

Lake Community Indices	Statistic	Interpretation
Number of Species Observed	13	
Bluegill Size Score	1	Very Poor
Bluegill Growth Index	Not Determined	Insufficient Data
Percent Bluegill/Pumpkinseed	75.0%	Satisfactory
Presence of 203 mm (8 in) Bluegill	None	Unsatisfactory
Percent Predators	16.0%	Unsatisfactory
Largemouth Bass Growth Index	Not Determined	Insufficient Data

Kelly and Price (1979) observed 10 species in Bass Lake. All species observed in 1979 were also observed in 2003 with the exception of black bullhead, longear sunfish, and Iowa darter. Numbers of black bullhead and longear sunfish observed in 1979 were not reported. Both black bullhead and longear sunfish have been observed in few other lakes. Other than Bass Lake, the only other waterbodies in which longear sunfish were reported by Kelly and Price (1979) were the Platte Lakes and North Bar Lake. Black bullhead were only reported in Bass Lake and the Crystal River (Kelly and Price 1979). It is difficult to know whether these species still persist in

Bass Lake. Iowa darter were observed in a seine haul in Otter Lake, and because seines were not employed in Bass Lake it is likely that the Iowa darter was simply missed in the survey. Species observed in 2003 but not in 1979 include Chinook salmon, coho salmon, central mudminnow, northern pike, white sucker, and black crappie. Chinook and coho salmon were observed in 2003 because they were migrating up the system to spawn. Kelly and Price (1979) performed their survey in August and would not have seen migratory Pacific salmon at that time of year. Pacific salmon run relatively late in this system. It is likely that white sucker and black crappie were also present in 1979 but were missed in the survey, as they were found in Otter Lake during the same period. In the 25 years since the last survey it is possible that central mudminnow and northern pike distribution may have moved slowly up from the lower Otter Creek system into Otter and Bass Lakes. It is not known whether northern pike were historically stocked in these lakes.

Deer Lake

Deer Lake is a small (1.8 ha [4.5 ac]) basin situated approximately 40 m (130 ft) upstream from Bass Lake. Basin structure and drainage are similar to Bass and Otter Lakes with cedar swamp to the north and south, grading to upland hardwoods along both western and eastern shorelines. Motors are prohibited in this lake, and access is generally limited to canoes and medium-sized boats. Bottom contours are uniform, with average depth of approximately 3.7 m (12 ft) and maximum depth of 6.7 m (22 ft). Bottom substrates are soft marl and organic muck. Much of the lake's water is likely input through groundwater along the southern shore. The shoreline is similar to that of Otter and Bass Lakes with moderate complexity, an abrupt bank, sharp drop-offs, and abundant large woody debris both in and adjacent to the water. Macrophytes are abundant and are distributed in patches throughout the lake with highest densities in cove areas. Beds are comprised chiefly of pondweed, muskgrass, water-lily, and coontail. Shoreline macrophytes include bulrush, sedges, and cattail. Water quality data collected in October 2003 yielded nothing remarkable. Slight chemical changes may be occurring; however, continued sampling to monitor these trends was cited in the 2003 water quality report by Murphy (2003).

Fishery surveys were performed in July 2004 using fyke nets and minnow traps. We sampled seven net nights (seven fyke nets for one night), and 14 minnow traps were fished for one night (Figure 20). Seine hauls were not conducted due to the soft muck bottom, sharp drop-offs, and abundance of woody debris. Ten species were collected: bluegill, pumpkinseed, largemouth bass, yellow perch, rock bass, black crappie, bluntnose minnow, northern pike, brown bullhead, and blacknose shiner (listed in order of numerical abundance). Table 13 summarizes fishery indices used to help describe the lake's fish community. Bluegill, pumpkinseed, and largemouth bass comprised the largest portion of the catch numerically, 83%, 12%, and 1%, respectively. The survey reflects abundant forage in this lake. The bluegill sample was dominated by stock size fish age 0, 1, and 2. Bluegill comprised the largest portion of the fyke net catch numerically and likely comprises the bulk of the gamefish biomass in the lake. As in Otter Lake and others there was a noticeable absence of desirable-sized bluegill (203 mm [8 in]). All species observed with large enough sample sizes to calculate growth indices had below average growth; however, most growth indices were calculated based on only one age class. Species aged were northern pike, pumpkinseed, rock bass, yellow perch, largemouth bass, bluegill, and black crappie. It should be noted that length at age for most of these species was below State average. Seven net nights yielded large numbers of juvenile bluegill and pumpkinseed which comprised 95% of the total catch by number.

This lake likely provides a poor fishery. As suggested above, following evaluation of a walleye stocking effort in Otter Lake (if it is approved by NPS policy and implemented), a similar prescription may be considered for Bass Lake and Deer Lake. Further surveys are recommended to better evaluate growth and survival of gamefish species and provide management options. Monitoring of exotic species abundance should also continue to evaluate impacts on the fish communities. The relatively recent infestations of zebra mussels in Otter and Bass Lakes and rusty crayfish in Otter Lake warrant continued monitoring for these species in Deer Lake.

Table 13. Summary of community indices for Deer Lake, Benzie County (2004).

Lake Community Indices	Statistic	Interpretation
Number of Species Observed	10	
Bluegill Size Score	1	Very Poor
Bluegill Growth Index	-0.91	Poor
Percent Bluegill/Pumpkinseed	94.0%	Unsatisfactory
Presence of 203 mm (8 in) Bluegill	None	Unsatisfactory
Percent Predators	6.0%	Unsatisfactory
Largemouth Bass Growth Index	Not Determined	Insufficient Data

Kelly and Price (1979) observed only three species in Deer Lake. All species observed in 1979 were also observed in 2004 with the exception of Iowa darter. Iowa darter were observed in a seine haul in Otter Lake, but because seines were not employed in Deer Lake it is likely that Iowa darter was simply missed in the survey. Species observed in 2004 but not in 1979 were bluegill, pumpkinseed, yellow perch, rock bass, black crappie, bluntnose minnow, brown bullhead, and blacknose shiner. It is unclear what gear types were used in the 1979 survey, and due to its unobstructed access to Bass Lake it is very unlikely that the species composition of Deer Lake changed significantly between 1979 and 2004. It is more likely that the species observed in 2004 but not in 1979 were simply missed in that survey because of gear types deployed.

Platte River Watershed

Little Platte Lake

Little Platte Lake is 147 ha (363 ac) and empties into the Platte River via a relatively short (1640 m [5380 ft]) low gradient channel locally known as the Deadstream of the Platte River. It is shallow throughout the basin with a maximum of depth of 2.4 m (8 ft). Most of the aquatic vegetation observed at the time of a MDNR survey in 1981 (described below) was submerged vegetation along the eastern shoreline. Only a small portion of its northern shoreline borders SLBE (Figure 21). We did not survey Little Platte Lake in 2003 or 2004, nor did Kelly and Price in 1979.

The only fishery information available was from a MDNR survey performed in June 1981 in which a total of 25 net nights (one gillnet and 24 fyke nets) yielded 12 species of fish: bluegill, pumpkinseed, brown bullhead, rock bass, white sucker, northern pike, largemouth bass, longnose gar, yellow perch, tiger musky, bowfin, and black crappie (listed in order of numerical

abundance). Carp were observed at the time of the survey, but were not collected. Table 14 summarizes fishery indices used to help describe the lake's fish community. Growth for most species was near State average; however, tiger musky, yellow perch, and largemouth bass did not provide large enough sample sizes to calculate growth indices. The general MDNR analysis indicated that the total number of fish observed in the survey was quite low for a lake its size. A good number of large bluegill and pumpkinseed were observed; the size score index indicated that the majority (96%) of the bluegill catch was above acceptable size of 152 mm (6 in). Pike abundance was low, possibly due to a lack of spawning habitat. It is also possible that the lake is susceptible to winterkill during severe winters.

Table 14. Summary of community indices for Little Platte Lake, Benzie County (1981).

Lake Community Indices	Statistic	Interpretation
Number of Species Observed	12	
Bluegill Size Score	6	Excellent
Bluegill Growth Index	-0.40	Satisfactory
Percent Bluegill/Pumpkinseed	50.0%	Satisfactory
Presence of 203 mm (8 in) Bluegill	37%	Excellent
Percent Predators	7.1%	Unsatisfactory
Largemouth Bass Growth Index	Not Determined	Insufficient Data

Little Platte Lake is scheduled for a fishery survey to be conducted by the Grand Traverse Band during the summer of 2007.

Mud Lake

Mud Lake is a shallow 8.5 ha (21 ac) lake draining into the Platte River approximately 1 km (0.6 mi) upstream from Loon Lake. The basin is relatively flat and contains approximately 1 m (3.3 ft) of loosely consolidated fine particulate organic matter (FPOM) floc nearly filling the basin and leaving, at its deepest point, only approximately 1 m (3.3 ft) of open water column. The bottom is comprised largely of sand, as determined by probing through the FPOM floc. The shoreline is limited in complexity (uniform and linear) and dominated by bulrush and sedge colonies. Gentle slopes to the water's edge define much of the shoreline, which contains limited large woody debris. Water-lilies are abundant throughout the basin. Surface temperature at the time of our survey in July 2004 was 25.5 $^{\circ}$C, but within the FPOM floc the temperature was approximately 15 $^{\circ}$C, indicating the potential influence of groundwater supplying the lake. We did not measure the discharge rate of the outflow of this lake, but it is likely greater than 0.1 m^3/s (3.5 ft^3/s).

A fishery survey was to be conducted on July 27, 2004, using fyke nets, electrofishing equipment, and minnow traps. However, due to the bottom composition (FPOM) and the resulting shallow water, we elected only to set minnow traps nearshore along the southern half of the lake, deployed from a canoe (Figure 22). The northern portion of the lake was impassable due to the FPOM suspension. Seven species were collected: bluegill, pumpkinseed, largemouth bass, sand shiner, Iowa darter, central mudminnow, and yellow perch (listed in order of numerical abundance). Kelly and Price (1979) observed nine species in Mud Lake. Only two species observed in 1979 were also observed in 2004: bluegill and sand shiner. Species observed

in 2004 but not in 1979 include pumpkinseed, yellow perch, largemouth bass, Iowa darter, and central mudminnow. Due to its proximity to the Platte River it is likely that the fish community composition may vary temporally to a significant degree. This lake does not, and likely will never, offer any recreational fishery due to its shallow depth and high FPOM loading.

Loon Lake

Loon Lake is 37 ha (91 ac) in surface area and is a flow-through basin for the lower Platte River. The lake likely offers seasonal temperature moderation to the lower Platte River. The basin is relatively steep, particularly near the east end of the lake. It is largely surrounded by lowland conifer and swamp, including a peat bog along the western shore. Motors are permitted in this lake, and access is available through a hardened boat launch. Bottom contours are uniform, with average depth of approximately 9 m (30 ft) and maximum depth of 19 m (63 ft) at the south end of the lake. Bottom substrates are sand, marl, and organic muck with areas of gravel along the eastern shoreline south of the boat launch. The shoreline has moderate complexity, with an abrupt encroaching bank along the western shoreline, relatively sharp drop-offs, and moderate levels of large woody debris both in and adjacent to the water, particularly between the river inlet and outlet. Macrophytes, consisting chiefly of pondweed, muskgrass, water-lily, elodea, and coontail, are moderate to heavy in abundance and are distributed in patches throughout the littoral zone with highest densities in cove areas. Shoreline emergents include colonies of bulrush, sedges, and cattail. Purple loosestrife is established at several points along the shoreline. Annual control efforts are carried out by NPS staff.

Fishery surveys were performed in August 2004 using fyke nets, boomshocking, seines, and minnow traps. We sampled 14 net nights (seven fyke nets for two nights), and 16 minnow traps were fished for one night (Figure 23). Five seine hauls were conducted where the shoreline was wadeable. A nighttime boomshocking survey was conducted with a total shock time of 1.25 hr. Twenty-three species were collected: pumpkinseed, rock bass smallmouth bass, bluegill, common shiner, Johnny darter, yellow perch, bluntnose minnow, largemouth bass, hornyhead chub, white sucker, brown bullhead, longnose gar, common carp, bowfin, central mudminnow, sand shiner, northern pike, walleye, channel catfish, alewife, spot-tail shiner, and sea lamprey (listed in order of numerical abundance). Table 15 summarizes fishery indices used to help describe the lake's fish community. Pumpkinseed, rock bass, and smallmouth bass comprised the largest portion of the fyke net catch numerically, 38%, 23%, and 17%, respectively. The survey reflects abundant forage in this lake, including centrarchids and cyprinids. Pumpkinseed, rock bass, and bluegill samples were dominated by stock size fish age 0, 1, and 2. Bluegill growth and size scores indicate an average fishery. Six age classes of bluegill were observed, but only one yielded a large enough sample to calculate a growth index (+0.39). With the exception of bluegill, the growth of species yielding large enough samples to calculate growth indices (pumpkinseed and rock bass) was below State average. Seven age classes of smallmouth bass were collected during the survey, but only two yielded large enough samples (>5) to generate growth indices. From these two year classes (ages 1 and 2) a growth index was calculated and found to be considerably below State average (-2.07).

Loon Lake is another instance where, due to the apparent lack of representative data, it is difficult to interpret the fish community. It is not known how successful anglers are on this lake; however, anecdotal information suggests that this lake receives a fair amount of angling pressure and that success can be quite good. Though only one walleye was observed during our survey,

this lake is known to provide a decent walleye fishery seasonally. The largest fish observed during our survey were smallmouth bass (450 mm [17 in]) and bowfin (610 mm [24 in]).

Table 15. Summary of community indices for Loon Lake, Benzie County (2004).

Lake Community Indices	Statistic	Interpretation
Number of Species Observed	23	
Bluegill Size Score	3	Acceptable
Bluegill Growth Index	+0.39	Average
Percent Bluegill/Pumpkinseed	49.0%	Satisfactory
Presence of 203 mm (8 in) Bluegill	2%	Good
Percent Predators	24%	Satisfactory
Smallmouth Bass Growth Index	-2.07	Poor
Largemouth Bass Growth Index	Not Determined	Insufficient Data

Kelly and Price (1979) observed only three species in Loon Lake: pumpkinseed, rock bass, and shorthead redhorse. It is unclear what gear types and effort were employed in their survey. We did not observe shorthead redhorse in our 2004 survey; however, this lake's fish community can vary greatly due to its connection to Lake Michigan via the Platte River. It is very likely shorthead redhorse continue to occupy Loon Lake, as they are relatively common in large riverine systems and impoundments. It is logical that the top two species in our survey were the same species observed in 1979, but it is rather puzzling that no other species were observed, given our findings and the diversity found by Kelly and Price (1979) in the connecting Platte River. Loon Lake produced by far the most diverse fish community of all of the lakes surveyed in SLBE in 2003 or 2004 with 23 species, and this high diversity can be attributed to its connection with the Platte River.

Lower Platte River

The watershed of the Platte River, including the North Branch, covers more than 192 km^2 (74 mi^2) extending into Grand Traverse and Leelanau Counties. Only a portion of this watershed (70 km^2 [28 mi^2]) and approximately 7 km (4.5 mi) of the Platte River mainstem is situated within SLBE (Figure 24). This portion of the river, classified as coolwater, is inhabited by warmwater to coolwater fish species such as rock bass and river minnows, with seasonal migrations of salmonids including steelhead, brown trout, coho, and Chinook salmon. Substrates are primarily sand with some gravel pockets near the mouth and the lower salmon harvest weir. A fishery survey is planned for summer 2007 or 2008. Figure 25 depicts the survey locations, effort, and species observed.

Kelly and Price surveyed the lower Platte River at six sites in 1979, but observed only seven species. The Platte River was cited as having the most diverse fish assemblage within SLBE. This is largely due to its unique temperature regime. Its headwaters are lake fed by warm water; then moderated by a significant contribution of groundwater from just above the MDNR hatchery (approximately 2.5 km [1.5 mi] east of Honor) down to Platte Lake, causing a reversed temperature gradient; then once again warmed by both Big and Little Platte Lakes. This unique temperature gradient, coupled with its connected lake systems, produces an exceptionally diverse fish community.

Other Small Watersheds

Good Harbor Creek

Good Harbor Creek is a small tributary to Good Harbor Bay, Lake Michigan, situated at the northern end of SLBE in Leelanau County. It is a short stream (approximately 1300 m [4265 ft] in length) originating from multiple groundwater seeps discharging from a cedar swamp located within and between pre-historic shoreline benches. Approximately 300 m (984 ft) from the mouth, the stream is impounded by a large beaver dam. It appears from aerial photos dating back to 1992 that this impoundment has been in existence for a number of years. The impoundment is approximately 0.6 ha (1.5 ac) in surface area and in places exceeds 3 m (10 ft) in depth. The elevation difference between the lower stream and the impoundment is approximately 2 m (6.5 ft). Though not directly measured, discharge from the impoundment is likely <0.1 m^3/s (3.5 ft^3/s) and may periodically cease to flow. Substrates are composed largely of sand and muck in both the stream and impoundment. The impoundment likely warms water temperatures in this stream significantly.

A fishery survey was performed on May 10 and May 12, 2004, using a backpack electrofisher. The electrofisher was deployed from a canoe to sample the beaver impoundment. The stream was surveyed from the mouth to the impoundment (approximately 300 m [984 ft]) and throughout the impoundment basin (Figure 26). An attempt was made to locate the stream above the impoundment, but only several very small rivulets were found emerging from various locations and were not sampled. A total of 45 min of shock time was recorded. Seven species were collected: banded killifish, northern redbelly dace, central mudminnow, pumpkinseed, bluntnose minnow, bluegill, and brown bullhead (listed in order of numerical abundance). The stream and the impoundment have similar species composition.

Kelly and Price did not survey this stream in 1979. The warmwater species composition corroborates our observation of the impoundment warming this stream. This system offers no significant sport or subsistence fisheries. The impoundment provides significant wildlife habitat for beaver, otter, and waterfowl.

Hidden Pond

Hidden Pond is a small (0.6 ha [1.5 ac]), shallow pond situated at the base of a large dune east of Pyramid Point. Average depth is approximately 0.4 m (1.3 ft); however, beaver occupy this pond and have excavated deeper (0.9-1.2 m [3-4 ft]) channels leading to a lodge at the north end of the pond. There are no obvious surface inlets or outlets. Most of its drainage comes from a cedar swamp surrounding the pond, with the largest portion southwest of the basin and at the foot of the dune. The bottom is largely organic muck with large beds of muskgrass and water-lily. Small pockets of sand mixed with detritus were evident in beds of spawning pumpkinseed. Water quality parameters measured on two occasions in late June revealed nothing remarkable. Surface temperature was 21 $^{\circ}C$ and dissolved oxygen ranged from 84% to 65% (7.4 to 5.9 ppm), surface to bottom.

A fishery survey was performed on June 20, 2003, using a backpack electrofisher deployed from a canoe. A total of 5.8 min of shock time was recorded. Four species were collected: northern redbelly dace, pumpkinseed, bluegill, and fathead minnow (listed in order of abundance). Figure 27 summarizes species caught, effort, and electrofishing courses.



Spawning Pumpkinseed

Kelly and Price (1979) observed three species in their survey. Brook stickleback were observed in 1979 but not in 2003. Neither bluegill nor pumpkinseed were observed in 1979, but both were seen in 2003. As noted above, pumpkinseed were observed spawning in small pockets near the shore of the pond. Because of the low fecundity of stickleback it is very likely that bluegill and pumpkinseed have displaced any stickleback. Hidden Pond was the only waterbody surveyed in 2003 where northern redbelly dace and fathead minnow were observed. Fathead minnow is a common species used for bait by anglers. It is interesting that they were observed only in this small waterbody.

Hatt Pond

Hatt Pond is a small (0.7 ha [1.7 ac]), shallow pond situated approximately 0.3 km (0.2 mi) south and east of Hidden Pond and 0.2 km (0.1 mi) north and west of Shell Lake. Its drainage is relatively flat upland hardwoods, and it is largely supplied by surface water. It appears that the size of the basin may change as a result of fluctuations in annual precipitation. Average depth is slightly greater than 0.3 m (1 ft). Beaver occupy this pond and may periodically modify the bottom topography. There are no obvious surface inlets or outlets. The bottom is largely organic muck with large beds of pondweed, muskgrass, and water-lily. Water quality parameters measured on June 18, 2003, revealed nothing remarkable for a small pond. Surface temperature was relatively high (27.9 $^{\circ}$C), and dissolved oxygen was supersaturated at 140% and 10.9 ppm.

A fishery survey was performed on June 18, 2003, using a backpack electrofisher deployed from a canoe. Total shock time was 11.5 min. Central mudminnow was the only species collected in the pond. Figure 28 summarizes species caught, effort, and electrofishing courses. No previous survey records were available for this waterbody.

Taylor Lake

Taylor Lake is a small, 1.3 ha (3.2 ac) lake perched in upland hardwoods approximately 350 m (1148 ft) east of M-22 and about 0.6 km (0.4 mi) north of Stormer Road in Leelanau County. Its drainage is rolling upland hardwoods, and it is largely supplied by surface water. Average depth is approximately 2 m (6.6 ft), and the central portion of the lake is dominated by a floating mat

of sphagnum moss (*Sphagnum magellanicum)* (Figure 29). A diverse community of plants was observed, both on the floating mat and nearshore, including water smartweed *(Polygonum amphibium),* wild celery *(Vallisneria americana),* water-lily, and cattail. No surface inlets were clearly evident; however, an outlet discharging from the southern end was observed. The bottom is largely organic muck, sand, and clay. Water quality parameters measured on May 17, 2004, revealed nothing remarkable. Dissolved oxygen was 6.7 ppm, and temperature ranged from 11- 16 °C.

A fishery survey was performed on May 17, 2004, using a backpack electrofisher deployed from a canoe. A total of 27.6 min of shock time yielded no fish. Figure 29 illustrates the approximate survey route. As indicated above, the survey occurred during spring when water levels were highest. It appears that a large portion of this pond is inundated only seasonally, particularly the areas outside of the floating sphagnum mat. No previous survey records were available for this waterbody.

Beck Pond

Beck Pond is an old stock pond <1 ha (2.5 ac) in area, situated approximately 50 m (164 ft) north of Stormer Road and about 300 m (984 ft) east of M-22 in Leelanau County. Its drainage is relatively flat upland hardwoods, and it is largely supplied by surface water. Average depth is approximately 0.3 m (1 ft). A surface inlet enters from the northwest and an outlet discharges on the east shore. The bottom is largely organic muck and clay. Little aquatic vegetation was observed except sparse cattails and pondweed. A few small trees have fallen into the pond, offering the only shoreline structure. Water quality parameters measured on June 9 revealed nothing remarkable for a small pond, except for high levels of suspended solids due to recent rain events and the clay soils. Surface temperature was 20.9 °C, and dissolved oxygen was 71% and 6.2 ppm.

A fishery survey was performed on June 9, 2004, using a backpack electrofisher deployed from a canoe. A total of 6.2 min of shock time was recorded. Figure 30 illustrates the approximate survey route. Green sunfish and white sucker were the only species collected in the pond. With the exception of Manitou Lake (discussed later) this was the only waterbody within SLBE containing green sunfish. These were likely stocked to provide a recreational fishery for the previous owner of the property. Green sunfish ranged from 73-156 mm (2.9-6.1 in) in length, and white sucker lengths were 301 mm (11.8 in) and 304 mm (12 in). No previous survey records were available for this waterbody.

Esch Road Pond

Esch Road Pond is a small, un-named old stock pond <1 ha (2.5 ac) in area, situated approximately 20 m (66 ft) south of Esch Road and about 160 m (525 ft) west of M-22 in Benzie County. Its drainage is an old farm field being colonized by aspen, white pine, and willow. The pond is likely supplied largely by surface water. Average depth is approximately 2 m (6.6 ft). No surface inlets or outlets were evident. The bottom is largely organic muck and clay. The shoreline is abrupt with several small trees protruding into and over the pond offering the only shoreline structure. Water quality parameters measured on June 9 revealed nothing remarkable for a small pond. The water was dark in color, likely due to tannins from adjacent conifers and low topography.

A fishery survey was performed on June 9, 2004, using a backpack electrofisher deployed from a canoe. A total of 2.8 min of shock time yielded no fish. It is possible that additional survey efforts may yield fish observations; however, we are rather confident that, based on the structure and cover we electrofished, if there were fish present we would have observed them. Figure 31 illustrates the approximate survey route. No previous survey records were available for this waterbody.

Peterson Road Ponds

Approximately 1.5 km (0.9 mi) from M-22 on Peterson Road is a group of small inter-dunal ponds that are seasonally inundated and interconnected. Later in the year these ponds shrink in size, disconnect, and largely dewater. They range in size from 0.1 ha (0.25 ac) to >4 ha (10 ac) in surface area. Figure 32 illustrates some of these ponds. They drain primarily upland hardwoods, are fringed by lowland conifer pockets, and are largely supplied by surface water. Average depth is approximately 1 m (3.3 ft), and they contain substrates largely comprised of sand, gravel, and organic matter. Aquatic vegetation observed during the survey included bulrush, sedges, and pond lily. Water temperatures in these shallow ponds likely elevate rapidly and significantly during the summer months. Water temperature on May 13, 2004, was 20 °C.

A fishery survey was performed on May 13, 2004, using a backpack electrofisher deployed from a canoe. A total of 29.8 min of shock time yielded no fish. Figure 32 illustrates the approximate survey route. As indicated above, the survey occurred during spring when water levels were high and temperatures were low. It appears that a large portion of the pond we surveyed, and likely others, is inundated only seasonally and likely experiences very high summer temperatures, resulting in particularly harsh conditions for most species of fish. No previous survey records were available for this waterbody.



Inter-dunal Pond

Boekeloo Road Ponds

Beginning at Boekeloo Road to the west of M-22 in Benzie County and proceeding approximately 3 km (1.9 mi) south there are, in most years, nearly three dozen small inter-dunal ponds situated in the depressions between historic shoreline benches. In wet years it is likely many more of these ponds persist as evidenced by the aerial photograph in Figure 33. Figure 33 illustrates the ponds surveyed in 2006 and the findings of the surveys. Most of these ponds are ephemeral and likely freeze to the bottom if they persist annually. Some of the largest ponds are 2-3 ha (5-7 ac) in surface area. The ponds are generally shallow, <3 m (10 ft) deep, and are largely filled with mats of muskgrass and fringed by cattail, bulrush, and sedges. The water is often stained with tannin and warms to a significant degree during summer. Due to the

remoteness of most of these ponds we were unable to sample them for fisheries with the exception of one near the end of Boekeloo Road. We visited several of the ponds by foot and took general observations of their character and composition. We believe the pond we sampled at the end of Boekeloo Road offers a representative fishery sample for these ponds collectively. Given their relative size, temperature regimes, and proximity to other lakes or streams, it is highly unlikely they contain any species other than those found in the Boekeloo Road Pond. This pond is adjacent to a small cabin, likely used historically for hunting and recreation. Of the group of ponds, we expected this pond to be the most likely to contain fish.

The fishery survey was conducted in July 2006, using a backpack electrofisher deployed from a canoe. Total effort was 14.9 min of shock time, and the only species observed was central mudminnow. A total of 65 fish were captured. Water temperature at the time of the survey was 23 °C. Other details pertaining to the sampling method are found in Figure 33. These lakes have not been surveyed previously.

Bow Lakes

Comparable to Taylor Lake approximately 12 km (7.5 mi) to the southwest, Bow Lakes are comprised of three small lakes and one bog, totaling approximately 6 ha (14.8 ac) in area, perched in upland hardwoods in central Leelanau County. They drain steep topography containing upland hardwoods and are largely supplied by surface water. Figure 34 is an aerial photo of Bow Lakes. These lakes were not surveyed because access was limited by private ownership of land surrounding the ponds. These lakes have not been surveyed previously.

North Bar Lake

North Bar Lake is a 12.1 ha (30 ac) basin that was once a coastal embayment of Lake Michigan and that is now separated from Lake Michigan by low sand dunes. It is connected to Lake Michigan via a wide shallow channel that is periodically blocked by longshore drifts of sand. Motors are prohibited in this lake, and access is generally limited to canoes and medium to small boats. Bottom contours reflect the surrounding varied topography; the basin is narrow and deep with an average depth of approximately 4.6-6.1 m (15-20 ft), with the deepest point 9.5 m (31 ft). Bank contours exhibit moderate to sharp drop-offs throughout the lake. The substrate is largely sand with muck deposition in the deeper portions of the lake. The shoreline exhibits moderate complexity with average distribution and abundance of woody debris and is dominated by sedge and bulrush colonies. Most of the shoreline exhibits an abrupt bank with the exception of the north end where sloped sand beaches occur. Macrophytes are average in abundance. The majority occur in the shallower portion of the lake at the south end and are comprised chiefly of pondweed, muskgrass, water smartweed, and water-lily. Water quality parameters measured on June 25, July 1, and July 8 revealed nothing remarkable. Surface temperatures ranged from 21.6-24.8 °C. Dissolved oxygen ranged from 117.5% to 1.5% (10.5 to 0.16 ppm), surface to bottom. On at least two occasions dissolved oxygen at the surface was approximately 1 ppm lower than at mid-depth. The lake had stratified by the first sampling session in June.

Fishery surveys were performed in July 2003 using fyke nets, seines, and minnow traps. In order to avoid excess mortality, gillnets were not used because dissolved oxygen at or near the bottom was below 2 ppm. We sampled eight net nights (four fyke nets for two nights), and 13 minnow traps were fished for one night. A total of seven seine hauls were conducted in several locations

where the shoreline was wadeable (Figure 35). A total of 13 species were collected: bluegill, sand shiner, bluntnose minnow, smallmouth bass (largely fry), rock bass, banded killifish, Johnny darter, yellow perch, pumpkinseed, brook silversides, northern pike, brown bullhead, and largemouth bass (listed in order of numerical abundance). Table 16 summarizes fishery indices used to help describe the lake's fish community. Bluegill, sand shiner, and bluntnose minnow comprised the largest portion of the catch numerically, 40%, 21%, and 12%, respectively. The survey reflects a significant forage base in this lake. Most notable are large numbers of age 1 and 2 bluegill in addition to an abundance of cyprinids. To avoid excess mortality of minnows, the catch of one seine haul was estimated rather than conducting a full count. Schools of cyprinids in excess of 1,000 were not uncommon. Bullhead were very low in abundance. Bluegill comprised the largest portion of the fyke net catch and likely comprised the bulk of the gamefish biomass in the lake. Growth of bluegill was slightly below State average. No 203 mm (8 in) bluegill were observed in the surveys. Two age classes of largemouth and smallmouth bass were aged, but neither provided large enough samples to calculate a growth index (Table 16). The only other species with large enough samples to calculate a growth index was rock bass, which had a growth index only slightly higher than State average. It should be noted that rock bass had a lower growth rate in this lake than in any other surveyed lake.

Table 16. Summary of community indices for North Bar Lake, Benzie County (2003).

Lake Community Indices	Statistic	Interpretation
Number of Species Observed	13	
Bluegill Size Score	1	Very Poor
Bluegill Growth Index	-0.4	Poor
Percent Bluegill/Pumpkinseed	84.0%	Unsatisfactory
Presence of 203 mm (8 in) Bluegill	None	Unsatisfactory
Percent Predators	2.1%	Unsatisfactory
Largemouth Bass Growth Index	Not Determined	Insufficient Data

Due to its proximity and connection to Lake Michigan, North Bar Lake has a significantly higher risk for exotic species introduction than most other lakes in SLBE. Zebra mussels, common carp, and alewife are known to occupy this lake. Zebra mussels have been present since 1997, but do not appear to be present in significantly high numbers. Secchi disc readings have not significantly increased, but total phosphorus and alkalinity have declined. Fish growth, particularly in early stages, can be directly related to nutrient loading in a lake.

Similar to Shell Lake, it is likely that bluegill populations in North Bar Lake are limiting early growth and recruitment of largemouth and smallmouth bass. It is not known how many adult bass are removed from the system by anglers. The abundant cyprinid forage is significant and likely reduces bass predation pressure on bluegill, thereby increasing competitive interactions with largemouth bass. Further surveys are recommended to better evaluate growth and survival of gamefish species and provide management options. Monitoring of exotic species abundance should continue to evaluate impacts on the fish communities.

Seven species were observed by Kelly and Price in 1979. The only species that were observed in 1979 but not in 2003 were spot-tail shiner and alewife. Spot-tail shiner and alewife are schooling

species, so it is possible that these species are still present but were simply missed in our survey. All other species observed in 1979 were also seen in 2003. Species observed in 2003 but not in any previous surveys listed in Kelly and Price (1979) include bluntnose minnow, common carp, banded killifish, brook silversides, bluegill, largemouth bass, pumpkinseed, and rock bass. Small yellow perch and alewife were the most abundant species observed in 1979. It is surprising that the 1979 survey did not produce bluegill, pumpkinseed, rock bass, or largemouth bass; however, fyke nets were not used in 1979, and this gear produced the majority of these species in 2003. These species were likely present in 1979, but missed in the survey.

Also noted in 2003 was the capture of five painted turtles and six snapping turtles, including one large specimen with age >20 yr. Several large beaver lodges are present on this lake, and beaver were observed maintaining a dam impounding a small stream flowing into the south end of the lake. A significant amount of the woody debris in this lake is provided by beaver activity.

Round Lake

Round Lake is 6.1 ha (15 ac) in area, largely bordered to the north by relatively steep contours containing upland hardwoods and conifers. The southern portion of its drainage is defined by low flat topography dominated by cattail marsh. The marsh comprises approximately 13 ha (32 ac) to the south of the lake and is bordered by cedar swamp. Motors are prohibited in this lake, and access is generally limited to canoes and small boats. It is the only lake assessed within SLBE that is part of the Crystal Lake watershed, and it is connected to Crystal Lake via a small stream flowing southward through the marsh described above. Round Lake receives input from a small stream on the southwestern portion of the lake. The lake basin is shallow with an average depth of approximately 2-3 m (7-10 ft) and maximum depth of 8 m (26 ft). The shoreline has limited complexity and is defined by gentle slopes along the northern half and an abrupt vegetative bank along the marsh shoreline to the south. Substrates are primarily sand with some gravel along the north shore. With the exception of beaver caches, large woody debris is widely distributed and relatively low in abundance throughout the shoreline. Bulrush, sedges, giant reed grass (*Phragmites australis*) and cattail are the predominant vegetation along the shoreline with pondweed and muskgrass present in moderate abundance. Water-lilies dominate the littoral zone along the southern shore of the lake. Water quality was not evaluated during the fishery survey conducted on this lake.

Fishery surveys were performed in July 2004 using fyke nets, seines, and minnow traps. We sampled 14 net nights (seven fyke nets for two nights), and 15 minnow traps were fished for one night. A total of two seine hauls were conducted in locations where the shoreline was wadeable (Figure 36). A total of 13 species were collected: sand shiner, yellow perch, bluegill, bluntnose minnow, pumpkinseed, smallmouth bass, largemouth bass, rock bass, banded killifish, Johnny darter, fathead minnow, and Iowa darter (listed in order of numerical abundance). Table 17 summarizes fishery indices used to help describe the lake's fish community. Sand shiner, yellow perch, and bluegill comprised the largest portion of the total catch numerically, 46%, 21%, and 16%, respectively. Bluegill comprised the largest portion of the fyke net catch numerically and likely comprised the bulk of the gamefish biomass in the lake. Growth of both bluegill and pumpkinseed is greater than State average with eight bluegill and five pumpkinseed age classes represented in the survey. Three age classes each of smallmouth and largemouth bass were aged, though none provided large enough samples to calculate the growth index presented in Table 17.

In general, Round Lake likely provides an average to good fishery. Bluegill and pumpkinseed appear to be its strongest fishery, but the lake is not very large and can likely support only minimal fishing pressure. Nearshore habitat could be improved with increased frequency and abundance of large woody debris or whole trees. Further surveys are recommended to better evaluate growth and survival of gamefish species.

Table 17. Summary of community indices for Round Lake, Benzie County (2004).

Lake Community Indices	Statistic	Interpretation
Number of Species Observed	13	
Bluegill Size Score	3.5	Acceptable
Bluegill Growth Index	+0.95	Good
Percent Bluegill/Pumpkinseed	66.0%	Satisfactory
Presence of 203 mm (8 in) Bluegill	Yes 8%	Good Population
Percent Predators	20%	Satisfactory
Largemouth Bass Growth Index	Not Determined	Insufficient Data

Kelly and Price (1979) observed nine species in their survey. Golden shiner and blacknose shiner were observed in 1979 but not in 2004. Golden shiners were observed in very low numbers in numerous seine hauls in Long Lake, just to the north of Round Lake, and it is a common species found in “bait buckets”. It is possible that this species persists in Round Lake today. We do not know what numbers of blacknose shiner were observed in 1979 or whether it currently persists in Round Lake. All other species observed in 1979 were also seen in 2004. Species observed in 2004 but not in any previous surveys listed in Kelly and Price (1979) include smallmouth bass, bluegill, pumpkinseed, Iowa darter, and fathead minnow.

Long Lake



Zebra mussels

Long Lake is 135 ha (326 ac) bordered on the south side largely by steep contours of upland hardwoods, and to the north by relatively flat mixed hardwood conifer stands. At both the east and west ends of the lake, lowland conifers dominate flat hydric soils. Bottom composition is chiefly soft marl and sand with sparse gravel pockets throughout. This lake is relatively shallow despite the upland topography trends. The steepest drop-offs are along the south shore of the lake. Average depth is approximately 2.5 m (7ft) with a maximum depth of 6 m (19 ft) near the central eastern portion of the lake. The shoreline has limited complexity (uniform and linear) with relatively gentle slopes to the water’s edge. Approximately half of the

shoreline is developed and limited in abundance of nearshore vegetation. The residences along the south shore at the west end of the lake have impacted the riparian and littoral zones to a greater extent than have the north shore residences, where these zones are largely undisturbed. Nearshore vegetated areas are dominated by bulrush and scattered colonies of sedge and cattail. The littoral zone has abundant large woody debris in low-level development areas. Submerged macrophytes include pondweed, and backbays are largely dominated by water-lily and broad-leaved arrowhead *(Sagittaria latifolia)*. Water quality was not evaluated during the fishery survey conducted on this lake. Surface temperatures at the time of the surveys ranged from 18-22 °C. Zebra mussels are present in Long Lake.

Fishery surveys were performed in August 2004 using fyke nets, seines, and minnow traps. We sampled 21 net nights (seven fyke nets for three nights), and 16 minnow traps were fished for one night. A total of nine seine hauls were conducted in locations where the shoreline was wadeable (Figure 37). Additionally, an electrofishing survey using two 5.5 m (18 ft) boomshocking boats was conducted the evening of September 22, 2004. Total electrofishing effort was 3.1 hr. Electrofishing routes included the entire shoreline and two mid-lake passes (Figure 37). A total of 14 species were collected: yellow perch, bluegill, largemouth bass, smallmouth bass, log perch, bluntnose minnow, banded killifish, Johnny darter, northern pike, sand shiner, rock bass, pumpkinseed, Iowa darter, and golden shiner (listed in order of numerical abundance). Table 18 summarizes fishery indices used to help describe the lake's fish community. Yellow perch, bluegill, and largemouth bass comprised the largest portion of the total catch numerically, 64%, 8%, and 6%, respectively. Yellow perch comprised the largest number of individuals caught during the survey, largely due to the abundance of yearling fish captured in seine hauls. However, bluegill comprised the largest portion of the catch numerically in fyke nets, followed by largemouth and smallmouth bass; collectively these four species likely constitute the bulk of the gamefish biomass in the lake. Growth rates of bluegill, rock bass, and yellow perch are above State average with three, two, and two age classes contributing to the growth index calculations, respectively. Three age classes of pumpkinseed were observed but did not yield large enough samples to calculate a growth index. Six age classes each of smallmouth and largemouth bass were aged, with two and three ages producing large enough samples to calculate the growth indices, respectively (Table 18). Both species exhibited below average growth.

Kelly and Price did not survey this lake in 1979. The most recent fishery survey was performed by the MDNR in 1985 using experimental gillnets and large and small mesh fyke nets. The survey was conducted on two occasions in July and August, and revealed an abundant brown bullhead population (62% of the total catch) and a forage base largely supported by golden shiner. Northern pike was the most common predatory gamefish, nearly 5% of the total catch, while largemouth and smallmouth bass were sparse in abundance (1% and 2% of the catch, respectively). Bluegill (7%) were relatively low in numbers with pumpkinseed (14%) higher in abundance. The fishery in Long Lake has changed significantly over the past 20 yr: bullhead and golden shiner all but disappeared from the community, while bass and bluegill increased significantly. The abundance of piscivorous species is the likely control mechanism for species such as bullhead and golden shiner.

Table 18. Summary of community indices for Long Lake, Benzie County (2004).

Lake Community Indices	Statistic	Interpretation
Number of Species Observed	14	
Bluegill Size Score	4.5	Good
Bluegill Growth Index	+1.3	Good
Percent Bluegill/Pumpkinseed	30.0%	Satisfactory
Presence of 203 mm (8 in) Bluegill	Yes 35%	Excellent
Percent Predators	48%	Satisfactory
Smallmouth Bass Growth Index	-1.4	Poor
Largemouth Bass Growth Index	-0.7	Average

Today Long Lake likely provides an average to good fishery. Bass and bluegill appear to be its strongest fisheries, and the lake offers a variety of other gamefish species, including northern pike, yellow perch, and the occasional walleye. Though no walleye were captured during the fishery survey, historical anecdotal information suggests they can still be periodically caught today. Nearshore habitat could be improved in the developed areas with increased frequency and abundance of large woody debris or whole trees and natural revegetation on and near the shore. Further surveys are recommended to better evaluate growth and survival of gamefish species.

Rush Lake

Rush Lake is 48 ha (118 ac) located within the Platte River watershed, approximately 300 m (984 ft) east of Long Lake. It does not have any surface connection to the Platte River. It is a shallow lake <1m (3.3 ft) in depth with a soft organic bottom. It is largely surrounded by cedar swamps and has little development on its shoreline. At the request of Park officials we did not survey this lake due to its location relative to Park properties. It does not lie within SLBE, but was surveyed in 1979 by Kelly and Price. They reported capturing five species: northern pike, golden shiner, bluegill, pumpkinseed, and Iowa darter. They noted that the northern pike were heavily infested with ectoparasites.

North and South Manitou Islands

Lake Manitou

Lake Manitou, located on North Manitou Island, is 104 ha (257 ac) surrounded in large part by moderately sloping contours comprised of upland hardwoods with interspersed conifers. At both the north and south ends of the lake, lowland conifers dominate flat hydric soils. The lake is primarily supported by surface runoff. A small outlet exits the lake at the north end and was obstructed by beaver at the time of the survey. Bottom composition is predominantly sand and soft marl with abundant gravel, rock, and cobble pockets throughout. Bottom contours generally follow upland topography trends with the steepest drop-offs along the eastern shore of the lake. Average depth is approximately 6 m (20 ft) with a maximum of 13.7 m (45 ft). The shoreline has moderate complexity, with relatively gentle slopes to the water's edge. None of the shoreline is developed. Nearshore areas that are vegetated are dominated by bulrush and scattered colonies of sedge and cattail, in addition to a large colony of giant reed grass along the western shore. The littoral zone contains abundant large woody debris and submerged macrophytes, comprised

chiefly of pondweed and muskgrass. Surface temperatures at the time of the survey ranged from 18-19 ˚C.

Lake Manitou is one of only two lakes on North Manitou Island (see Tamarack Lake below), and access is limited to foot traffic. No motorized vehicles are allowed on the Island. A hiking trail approximately 3.5 km (2.2 mi) in length generally limits fishing access to shore fishing, as most visitors will not pack watercraft into the lake. The MDNR has imposed special bass regulations limiting the harvest to only one 457mm (18 in) bass in possession, using artificial lures only.

Fishery surveys were performed June 14-17, 2004. Seven fyke nets and two gillnets were set in combination for a total of 22 net nights. The two gillnets were fished for two nights only. Park Service staff and others set and tended 16 minnow traps fished over one night, and pulled 20 seine hauls in various locations throughout the lake (Figure 38). In total only six species were observed: yellow perch, smallmouth bass, green sunfish, white sucker, bluntnose minnow, and Iowa darter (listed in order of numerical abundance). Table 19 summarizes the total catch during the survey. Yellow perch, smallmouth bass, and green sunfish comprised the largest portion of the catch numerically; 58%, 14%, and 11%, respectively. Though not as prevalent numerically, smallmouth bass contributed a large portion of the gamefish biomass in the lake and contributed 9% of the total catch. However, the vast majority (89%) were below the legal limit of 457 mm (18 in). The largest bass caught was 497 mm (19.5 in). Spine and scale samples were collected from 110 yellow perch and 78 smallmouth bass for age analysis. Growth indices were calculated based on six age classes of smallmouth bass and two age classes of yellow perch. Smallmouth bass are growing slightly below State average (-0.95), and yellow perch appear to be near State average (+0.03). The bass were in the middle of a spawning phase, and this may have limited their movements. Numerous bedding bass were visually observed throughout nearshore areas with gradual slopes, but very few fish were "exceptionally" large. The largest perch was 345 mm (13.5 in). As mentioned earlier, we observed large numbers of several age classes of perch. Juvenile perch constitute the bulk of the forage in this lake.

Table 19. Lake Manitou catch summary, June 2004.

Species	Number
Yellow Perch	776
Green Sunfish	184
White Sucker	155
Smallmouth Bass	119
Bluntnose Minnow	111
Iowa Darter	3

In general, Lake Manitou provides a very good to excellent smallmouth bass fishery. Smallmouth are abundant and receive lower fishing pressure than mainland populations. Though very few 457 mm (18 in) or larger bass were observed (11%), it is likely there are some exceptionally large specimens in the lake. Not all bass in a population spawn annually, and guarding males tend to be smaller than their female counterparts (Baylis et al. 1993). Many of

the adult bass that we captured were guarding males. It is possible that the bass population is at a high enough density to subdue growth. Smallmouth bass mature between 2-4 yr for males and 3-5 yr for females, and average Michigan lengths are 190-365 mm (7.5-14.4 in) for males and 274-389 mm (10.8-15.3 in) for females (Coble 1975). Most of the bedding bass were aged seven and eight years and averaged 410 mm (16 in) and 440 mm (17 in), respectively. It is well known that fish at higher densities tend to grow more slowly than fish at lower densities. The yellow perch fishery also provides ample angling opportunity, though it is likely not exploited to the same extent as smallmouth, because most angling on this lake occurs during summer when adult yellow perch tend to be in deeper water offshore and are not easily accessible to shore-based anglers. Exploitation rates for smallmouth bass and yellow perch are not known; however, they are likely significantly lower than in SLBE's mainland lakes due to Lake Manitou's limited access. Green sunfish generally do not grow as large as bluegill and likely offer little in terms of a fishery; however, they do contribute to the forage for bass in this lake and are a predator of juvenile bass. Table 20 summarizes the community indices used to evaluate the fisheries in Lake Manitou. Because bluegill and largemouth bass are not present in this lake, we evaluated green sunfish and smallmouth bass where applicable.

Table 20. Summary of community indices for Lake Manitou, Leelanau County (2004).

Lake Community Indices	Statistic	Interpretation
Number of Species Observed	6	
Bluegill Size Score	Not Available	Not Available
Green Sunfish Growth Index	NA	NA
Percent Bluegill/Pumpkinseed*	18.0%*	Unsatisfactory
Presence of 203 mm (8 in) Bluegill	No	Unsatisfactory
Percent Predators	11%	Unsatisfactory
Smallmouth Bass Growth Index	-1.4	Below Average

* Bluegill/pumpkinseed niche not present, percent cited is for green sunfish which is a more piscivorous centrarchid than bluegill or pumpkinseed.

Kelly and Price did not survey Lake Manitou in 1979. The only previous data were from a survey conducted by Karl Lagler from the University of Michigan in 1945, in which only six species were observed: white sucker, smallmouth bass, green sunfish, yellow perch, Iowa darter, and mottled sculpin. Additionally, Charles (1975) reported the presence of brown trout in Lake Manitou, likely stocked while North Manitou Island was under private ownership. The only species that were noted previously but not in 2004 were mottled sculpin and brown trout. Mottled sculpin are cryptic, bottom-dwelling species and generally are not found in very large numbers in inland lakes. It is likely that they continue to exist today and were missed in our survey. Due to the absence of significant coldwater tributaries flowing into Lake Manitou, it is highly unlikely that brown trout exist currently in this lake. All other previously observed species are present today. The only species observed in 2004 but not in any previous surveys listed in Kelly and Price (1979) was bluntnose minnow. Bluntnose minnow are very common in the Great Lakes and in inland lakes and streams and typically find their way into lakes via any physical connection to such waters.

In 2004 we captured one crayfish and one snapping turtle with a carapace length approximately 720 mm (18 in). Several large beaver lodges are present on this lake, and beaver were observed maintaining a dam at the head of a small stream exiting the north end of the lake. A significant amount of the woody debris in this lake is contributed by beaver activity.

Tamarack Lake

Tamarack Lake is a small (4 ha [10 ac]), shallow (2.5 m [8.2 ft]) lake largely surrounded by lowland topography dominated by dense conifer stands including northern white cedar and tamarack. It lies approximately 2.5 km (1.5 mi) south of Lake Manitou on North Manitou Island and approximately 7.5 km (4.7 mi) from the ferry dock. There are no designated (clearly marked) trails to this lake. Due to its relative inaccessibility, we did not survey Tamarack Lake in our study, nor did Kelly and Price (1979). We sent a reconnaissance party to evaluate the logistics of conducting a survey on this lake and determined that the only feasible method of sampling was a backpack electrofisher deployed from a canoe. The observers also noted that the lake was overgrown with vegetation (*Chara*); this suggests that the lake is shallow and likely to warm significantly in the summer. The fish community is likely limited to species such as central mudminnow, cyprinids, and centrarchids. It is doubtful that a fishery exists in this lake.

Florence Lake

Florence Lake is the only significant waterbody on South Manitou Island. It is 32 ha (79 ac) in surface area and has a maximum depth of nearly 8 m (26 ft). It is elongated in shape, >1.25 km (0.8 mi) long and one-fourth as wide, comparable to North and South Bar Lakes on the mainland. It is largely surrounded by flat sandy soils dominated by northern hardwood forests, with small stands of lowland hardwoods and conifers at the southeast and northeast ends of the lake. The lake is primarily supported by surface runoff. Bottom composition is predominantly sand and soft marl with sparse gravel pockets along the eastern shoreline. Bottom contours are uniform, with average depth approximately 5 m (16 ft) and maximum depth of 7.9 m (26 ft). The shoreline has moderate complexity and relatively gentle slopes to the water's edge. Portions of the western shoreline have dense mats of cattail effectively creating an abrupt bank. None of the shoreline is developed. Nearshore vegetated areas are dominated by cattail, giant reed grass, and scattered sedge and bulrush colonies. The littoral zone contains relatively little large woody debris, with the exception of at least three beaver caches. Submerged macrophytes include pondweed and muskgrass mats, many of which were covered with heavy green algae. Surface temperature at the time of the survey was 20 $^{\circ}$C.

Fishery surveys were performed June 21-23, 2004. Seven fyke nets and two gillnets were set in combination to total 18 net nights. The two gillnets were fished for one full night only, and one 5 hr set. Park Service staff and others set and tended 21 minnow traps fished over one night, and pulled 14 seine hauls in various locations throughout the lake (Figure 39). We observed virtually the same species composition as in Lake Manitou, but in differing proportions and size classes, and one significant predatory species (northern pike) was present rather than the green sunfish found in Lake Manitou. Five species were observed: yellow perch, northern pike, smallmouth bass, bluntnose minnow, and Iowa darter (listed in order of numerical abundance). Yellow perch and northern pike comprised the largest portion of the fyke net catch numerically, 30% and 70%, respectively. No adult smallmouth bass were captured, but adults were observed. Bass spawning occurred before we sampled the lake. This lake is smaller and shallower than Lake Manitou, so it

warms at a faster rate and fish spawn earlier. Most of the smallmouth bass in the catch were fry and juveniles captured in seine hauls. It was puzzling that we didn't catch any adult bass, but it is likely that habitat and northern pike limit bass numbers to a significant degree in this lake. The bulk of the biomass in this lake is comprised of yellow perch and northern pike. Perch and crayfish are the principal forage. Crayfish are more abundant in this lake than in Lake Manitou. No other forage species were observed. A few Iowa darter were observed, but they would not contribute significantly to the forage base of the lake.

The northern pike population is stunted in this lake. This problem is typically remedied by the removal of a size limit on this species (as implemented by the MDNR here). Growth of northern pike is significantly below State average (-3.05). Older age classes of yellow perch were limited, and no age classes produced large enough samples to calculate growth indices.

As in Lake Manitou, because bluegill and largemouth bass are not present in this lake, the standard indices used previously did not apply to Florence Lake. This lake is dominated by predators and is supported by the yellow perch population (Table 21). The stunted northern pike population limits the fishery in Florence Lake. Most of the pike were less than 508 mm (20 in) and many appeared skinny. The absence of a size limit on northern pike can work to improve the fishery, but in order for it to work, anglers need to catch and keep pike. This is not likely occurring. Limited cover in this lake can also affect fish growth and survival. Additional fishery evaluations are recommended to monitor the efficacy of the existing regulations.

Table 21. Summary of community indices for Florence Lake, Leelanau County (2004).

Lake Community Indices	Statistic	Interpretation
Number of Species Observed	5	
Bluegill Size Score	Not Available	Not Available
Percent Bluegill/Pumpkinseed	Not Available	Not Available
Presence of 203 mm (8 in) Bluegill	No	Unsatisfactory
Percent Predators	70%	Unsatisfactory
Smallmouth Bass Growth Index	Not Available	Not Available

Kelly and Price did not survey Florence Lake in 1979. The only previous data were from a limnological survey in 1974-75 by Gannon and Stockwell (1978) in which only four species were observed: smallmouth bass, northern pike, yellow perch, and Iowa darter. All of these species persist today. Additionally, bluntnose minnow were observed in 2004 but not previously. This species is nearly ubiquitous in this region and is also commonly used for bait.

Also noted in 2004 was the capture of 23 crayfish, one snapping turtle, and 47 painted turtles. Painted turtles were very abundant in this lake; in fact, the largest number observed out of all lakes surveyed was in Florence Lake. At least two active beaver lodges, associated with large caches of submerged aspen, were observed on this lake. A significant amount of the woody debris in this lake is contributed by beaver activity.

Lake Michigan

In June 2006 we conducted daytime seine hauls at five locations along the Lake Michigan shoreline in a relatively uniform distribution throughout SLBE. We used a 45.7 m by 1.8 m (150 ft by 6 ft) seine with 2 mm (0.1 in) mesh. We conducted at least one seine haul per site and recorded the species and number caught. Water quality data were taken by NPS staff at the time of the surveys. NPS water quality data, collected on a weekly basis, are available in a separate report. Nothing remarkable was observed in the water quality parameters measured at the sites.

Good Harbor Bay


Juvenile Whitefish

Good Harbor Bay is situated in the northernmost portion of SLBE in Leelanau County and is sheltered to the west by Pyramid Point. Substrates are largely sand with large deposits of gravel and cobble nearshore in various locations, depending on intensity and direction of wave action. The only significant tributary into this bay is Shalda Creek. Figure 40 depicts the sample location within Good Harbor Bay near Good Harbor Creek at the end of County Road 651. A dock ruin located at this access point to Lake Michigan offers structure to spawning smallmouth bass. On June 19, 2006, we conducted one seine haul beginning at this ruin and proceeding west along the shore and extending approximately 50 m (164 ft) offshore. Seven species were observed in the sample: spot-tail shiner, whitefish, emerald shiner, alewife, longnose dace, sand shiner, and Chinook salmon (listed in order of numerical abundance). A significant number of juvenile whitefish averaging approximately 30 mm (1.2 in) indicate productive whitefish spawning shoals nearshore.

In September 1979 both evening and daytime surveys were conducted by Kelly and Price in Good Harbor Bay at the end of Lake Michigan Road and near Shalda Creek. No details on the number of hauls, size of the gear, or relative numbers of fish captured were indicated. Species captured included longnose dace, rainbow smelt, alewife, spot-tail shiner, and smallmouth bass. The only species observed in 1979 but not in 2006 were rainbow smelt and smallmouth bass. Smelt populations in 1979 were significantly larger than they are today, and smallmouth bass are still known to occupy the nearshore waters of Lake Michigan. Whitefish were not observed because our sample occurred in September, and whitefish generally move offshore in July and August. Sand shiner, emerald shiner, and Chinook salmon were also present in 1979, but were missed in our seine haul. No indication of seine length was given in the 1979 report.

Sleeping Bear Bay

Sleeping Bear Bay is situated on the west side of Pyramid Point and contains a significant amount of private beach owned by residents of Glen Arbor. Substrates are very similar to those found in Good Harbor Bay, except that gravel and cobble are likely more abundant. The only tributary to Sleeping Bear Bay is the Crystal River, which drains from the Glens, Fisher, and Tucker Lakes. Figure 41 depicts the sample location within Sleeping Bear Bay behind the historic cannery in Glen Haven. As at Good Harbor Bay, dock ruins located in this bay offer structure to nearshore fisheries, including smallmouth bass. On June 19, 2006, we conducted one seine haul beginning on the west side of the dock ruins behind the cannery, proceeding west and approximately 30 m (98 ft) offshore due to deep water. Four species were observed in the sample: round goby, Johnny darter, alewife, and longnose dace. Round goby have been observed only recently in Lake Michigan and were first observed locally within the past three years. Goby are a prolific predatory species that can spawn multiple times per year, and they prefer rocky habitats where many other nearshore native species reside. They are aggressive and consume nearly anything from insects and fish eggs to zebra mussels. We do not know how round goby may impact the native nearshore fisheries. Due to their aggressive nature and prolific spawning capacity, it is imperative that best efforts are made to prevent any introduction into inland lakes and streams. Unfortunately, recent anecdotal accounts have indicated round goby moving upstream in Shalda Creek. Recent die-offs of round goby have been observed within SLBE, likely caused by botulism poisoning stemming from decaying cladophora nearshore. Consequent to these die-offs, local fish-eating birds (loons, cormorants, gulls, and grebes) have been found dead along the shore, also likely due to botulism poisoning. Further monitoring and sampling are planned to verify the causative agents.

Kelly and Price surveyed Sleeping Bear Bay in September 1979 and observed alewives, cisco (lake herring), spot-tail shiner, and longnose dace. We did not observe cisco in our survey.

Bar Lakes Shoreline



Fish Workup Lake Michigan

The shoreline near North and South Bar Lakes is linear and exposed to the prevailing westerly waves and wind from Lake Michigan. A narrow strip of beach approximately 2.6 km (1.6 mi) long exists between properties owned by SLBE and the town of Empire, located to the south. North Bar Lake beach lies just to the north of this strip. Access to the beach is through a County Road just to the south of North Bar Lake. The only nearby tributaries into Lake Michigan are from North and South Bar Lakes. Figure 42 depicts the sample location near North Bar Lake. Comparable to the other Lake Michigan sites, nearshore habitat is comprised largely of featureless sand with scattered gravel and stone. Large amounts of filamentous algae were present at the time of the survey. On June 19, 2006, we conducted one seine haul proceeding south along the shore and 30 m (98 ft)

offshore due to unwadeable depths. Five species were observed in the sample: alewife, spot-tail shiner, lake whitefish, sand shiner, and emerald shiner (listed in order of numerical abundance). Round goby were not observed at this site. Kelly and Price did not survey this location in 1979.

Esch Road Shoreline

The shoreline at the end of Esch Road is comparable to that found at the Bar Lakes. It is also an exposed beach. Otter Creek enters Lake Michigan approximately 150 m (492 ft) south of Esch Road end. This site is located within Platte Bay. Figure 43 depicts the sample location relative to the creek mouth and road end. Habitat nearshore is also sparse, with substrates dominated by sand with some gravel and stone. Dock ruins persist near the creek from the historic town of Aral, though only a very small number (one or two) are still visible, and they offer little or no fish structure. On June 20, 2006, we conducted one seine haul proceeding south toward the mouth of Otter Creek and extending about 50 m (164 ft) offshore. Six species were observed in the sample: spot-tail shiner, sand shiner, lake whitefish, alewife, Chinook salmon, and banded killifish (listed in order of numerical abundance). Round goby were not observed at this site.

Kelly and Price (1979) collected large numbers of alewife and bluntnose minnow at this site in August 1979. We did not observe bluntnose minnow in our sample; however, we did collect large numbers in Otter Creek when we surveyed it previously.

Platte Bay Lake Michigan Road

Platte Bay is located in the southernmost portion of SLBE in Benzie County. The shoreline is exposed to prevailing westerly waves and wind from Lake Michigan and only offers shelter from weather from the south. Otter Creek and the Platte River are the only tributaries to Platte Bay. The Platte River enters the bay at the southernmost point defining the bay. Figure 44 depicts the sample locations near the mouth of the Platte River. Habitat nearshore is predominantly sand with significant deposits of gravel and stone at the shore's edge, indicative of the high gravel content of the bars situated at the mouth of the Platte River. On June 21, 2006, we conducted two seine hauls proceeding south at two locations, one north and one south of the mouth of the Platte River (Figure 44). A total of ten species were observed in the sample: round goby, alewife, Chinook salmon, spot-tail shiner, lake whitefish, common shiner, yellow perch, Johnny darter, sand shiner, and longnose dace (listed in order of numerical abundance). Six round goby were captured south of the mouth of the Platte River, and no goby were observed north of the mouth. Accordingly, it is very likely round goby exist throughout the Lake Michigan shoreline within SLBE despite the absence of this species in some samples.



Lake Michigan Seine Haul

Kelly and Price collected only two species, alewife and spot-tail shiner, while seining in September 1979. Because of their proximity to the Platte River, it is puzzling they didn't observe more species. However, there is no information available on their gear, effort expended, or exact location of their sample.

Summary

Kelly and Price (1979) observed a total of 76 fish species in SLBE, with the largest number of species (53) observed in the Platte River watershed. However, the tables developed by Kelly and Price (1979) showed a total of 62 species observed by all investigators cited in their report. Combining our investigations with Kelly and Price (1979) and the investigators cited in their report, a total of 65 species have been documented in SLBE. We identified 46 fish species in 30 lakes or ponds, five streams and a complex of springs surveyed in SLBE (Appendix I). Three of these species were not cited in Kelly and Price (1979) as having been observed in SLBE: lake whitefish, brook silversides, and round goby. Lake whitefish were likely simply missed in the earlier surveys, but undoubtedly were present. Brook silversides may have also been present, but were missed because it is a relatively uncommon species. Round goby is an exotic species that has been increasing in abundance recently in the nearshore areas of Lake Michigan. It is imperative that precautions be taken to prevent their introduction into inland lakes.

Including all investigations cited in Kelly and Price (1979), there were ten species with only one occurrence in the study area (i.e., found in only one waterbody). These species are: lamprey spp., silver lamprey, lake trout, lake chub, rosyface shiner, silver redhorse, brook silversides, ninespine stickleback, blackside darter, and fantailed darter. Additionally, there were only 13 species with less than three occurrences within the study area: American brook lamprey, chestnut lamprey, sea lamprey, longnose gar, rainbow smelt, muskellunge, fathead minnow, shorthead redhorse, black bullhead, slimy sculpin, green sunfish, walleye, and round goby (Appendix I).

The 76 species reported by Kelly and Price (1979) in the study area may include species assumed to reside in the study area because they are known to occupy Lake Michigan. There are several other species that are known to occupy Lake Michigan and may, on occasion, frequent the nearshore areas of SLBE. Additionally, other species have also been observed in inland waters of this immediate region, but were not listed as direct observations by any of the investigators cited by Kelly and Price (1979) or during our surveys. These include Atlantic salmon, lake sturgeon, splake, round whitefish, deepwater sculpin, pugnose shiner, brassy minnow, finescale dace, pearl dace, and gizzard shad.

The Platte River watershed has historically exhibited the greatest fish diversity in SLBE. The only waterbodies surveyed in the Platte River watershed in the 2003-2006 investigations were Loon and Mud Lakes. We did not survey the Platte River proper; however, this river should be surveyed as soon as time permits. As observed by Kelly and Price (1979), a general trend exists from north to south, with higher species diversity in the southern portions of SLBE. Our data show that the type of waterbody also significantly influences species composition, with much greater species diversity in streams than in lakes (Figure 45). For Lake Michigan sites a trend of increasing species diversity from north to south is evident (Figure 45).

Habitat diversity and connection to Lake Michigan play significant roles in contributing to species diversity in SLBE streams. Lakes with connection to Lake Michigan also generally had higher species diversity. The small isolated lakes and ponds exhibited the lowest fish species diversity. The only notably rare species observed in the 2003-2006 surveys as cited by Kelly and Price (1979) was mimic shiner. This species was observed in measurable numbers in four lakes

in the Shalda Creek watershed, and it may be present in others. However, due to the potential confusion of this species with sand shiner, further investigation into its distribution through confirmed identifications is advised. Eight exotic species were observed in the 2003-2006 surveys, all of which were introduced intentionally with the exception of sea lamprey and round goby. Exotic salmonids provide sport fisheries in most of the Lake Michigan tributaries situated in SLBE. The only exotic species observed in 1979, but not in 2003, 2004, or 2006, was rainbow smelt. The only exotic fish species captured in 2003, 2004, or 2006, but not in 1979, were sea lamprey and common carp in Loon Lake. Common carp were captured in 1979 in North Bar Lake, but only visually observed in 2003. Distribution of other exotic fishes observed in earlier surveys has not expanded within SLBE since 1979. However, other aquatic nuisance species have recently been discovered in SLBE and are currently being monitored for changes in distribution. In or near SLBE, zebra mussels currently occupy Loon Lake, Long Lake, North Bar Lake, Deer Lake, Bass Lake, Otter Lake, Big and Little Glen Lakes, and possibly others. Rusty crayfish (*Orconectes rusticus)* was observed for the first time in Otter Lake during the 2003 surveys. Round goby were observed at two Lake Michigan sites in 2006 (Sleeping Bear and Platte Bays). This species was only recently observed in SLBE waters and will likely increase in abundance over time. It is an aggressive and prolific species that preys on eggs, young fish, and invertebrates. Its life history and habits often have significant negative impacts on nearshore fisheries through competition and predation. It is imperative that precautions be taken to prevent this species from entering inland waters. Annual surveys for aquatic nuisance species should continue to monitor changes in distribution and abundance over time.

Recommendations

The current Resource Management Plan for SLBE cites fishery related objectives (future needs) as:

1. Initiate a comprehensive study of the park's fish and aquatic habitats.
2. Cooperate with Michigan DNR to establish fisheries management and other aquatic resource goals.
3. Study and gather baseline data for water quality of all park lakes.
4. Prepare plans for management of park lakes and streams that will provide for continued resource protection while providing for visitor recreational opportunities.

The SLBE Water Resources Management Plan cites the following objectives:

1. Manage waters of the lakeshore and water-dependent environments in a manner designed to maintain the highest degree of biological diversity and ecosystem integrity.
2. Allow natural fluvial and lacustrine processes to proceed unimpeded, to the extent possible.
3. Assure that park development and operations do not adversely affect the lakeshore's water resources and water-dependent environments.
4. Acquire sufficient knowledge about water quality to effectively participate in state and local management planning and seek the highest level of protection under state water quality standards appropriate for the lakeshore.
5. Acquire appropriate baseline information to adequately understand and manage water resources and meet National Park Service inventory and monitoring requirements.
6. If possible, control or eradicate non-native species with an emphasis on the protection and restoration of native species.
7. Promote public awareness and understanding of current and potential human impacts upon water resources.
8. Provide for quality, environmentally sensitive recreational opportunities (e.g. fishing, canoe/kayak).
9. Detect and evaluate external influences on natural upland processes that may impact lakeshore water resources and water-related attributes.

The MDNR Fisheries Mission states: *To protect and enhance fish environments, habitat, populations, and other forms of aquatic life and promote optimum use of these resources for the benefit of the people of Michigan.*

Considering fishery surveys in the above context, the results of such surveys can be used to assist in developing site-specific management objectives and prescriptions designed to accomplish these large scale agency goals and objectives. Providing useable and productive fisheries to the public is key to maintaining support of resource management activities.

Appropriateness of Special Regulations

Most lakes within SLBE have restrictions on access and the use of motorized equipment. Given this, these lakes may provide unique fishery management opportunities. Approximately 6% of the 60 lakes currently managed under special regulations by the MDNR for "quality-trophy" fisheries are situated in the northern lower peninsula of Michigan. Although describing fisheries with terms like "quality" or "trophy" can be subjective, in the context of this report they describe a condition of having a high probability (>50%) of catching significant numbers of fish that fit criteria established by Gablehouse (1984) describing "quality", "preferred", "memorable", and "trophy" sized fish (Table 22). Catch-and-release regulations on top predators are the most common tool used in the management of these lakes for "quality-trophy" fisheries. Unfortunately, catch-and-release regulations are better suited for preserving *exceptional* fisheries rather than restoring average or poor fisheries (Schneider 2001). Further, it has been shown that, in situations where even minimal harvest of large bass is allowed, such regulations are considerably less successful at protecting bass populations and fishery quality than in situations that are completely no-kill. Allowance of one 457 mm (18 in) smallmouth bass in the Sylvania Tract resulted in a significant loss of "trophy" sized smallmouth bass (Clady et al. 1975; Latta 1975).

Table 22. Maximum total length in inches for five size designations (excerpted from Gablehouse 1984).

	Size Designation (in)				
Species	Stock	Quality	Preferred	Memorable	Trophy
Largemouth Bass	8	12	15	20	25
Smallmouth Bass	7	11	14	17	20
Walleye	10	15	20	25	30
Sauger	8	12	15	20	25
Muskellunge	20	30	38	42	50
Northern Pike	14	21	28	34	44
Bluegill	3	6	8	10	12
Green Sunfish	3	6	8	10	12
Pumpkinseed	3	6	8	10	12
Rock Bass	4	7	9	11	13
Black Crappie	5	8	10	12	15
Yellow Perch	5	8	10	12	15
Black Bullhead	6	9	12	15	18

Only one lake within SLBE is suited for a "quality-trophy" fishery at some level. Lake Manitou contains a robust smallmouth bass population. This is due largely to its exceptional nearshore habitat and healthy forage base, coupled with its relative inaccessibility to, and use by, large numbers of anglers, particularly those fishing from watercraft. Currently, one 457 mm (18 in) bass is allowed daily with possession of one day's limit. This allows for selected mortality of larger fish that can potentially limit the abundance of "trophy" fish through cropping. Furthermore, there is an indication that enforcing the existing creel limit is difficult--further lessening the efficacy of this regulation in accomplishing its intended goal. One solution to the enforcement issue, while potentially improving the abundance of larger fish, would be to impose

a no-possession regulation for smallmouth bass. In general, this lake is fished by individuals or groups that backpack to the lake and camp for any number of days. It is not known how many anglers rely on bass for sustenance while camping near the lake, but bass are generally not known as good table fare. Conversely, if bass prove to be an important source of sustenance for camping anglers, an option could be to offer a slot limit allowing for two smallmouth between 30.5 and 35.6 cm (12 and 14 in) with possession being no more than one day's limit. In either case, the premise would be to maintain Lake Manitou as a "quality-trophy" smallmouth bass fishery. Consultation with local MDNR fishery staff should be pursued to discuss these and other options.

The use of regulations as implemented on Lake Manitou is not necessarily appropriate for other lakes within SLBE. Because most of the lakes that provide fisheries show deficiencies in community structure and balance, it is likely not worth the effort to restrict harvest in order to provide "quality-trophy" sized fish. In fact, some relaxation in regulations may be appropriate in some lakes to help reduce the numbers of overabundant bass or other species' populations and increase growth. Consultation with local MDNR fishery staff should be pursued to discuss these and other options.

Monitoring

Harvest: Angling pressure and harvest monitoring can be a useful tool in fishery management; however, this can be very effort intensive depending on resolution of the data desired. Because of cost and personnel limitations, pressure and harvest estimates are not typically measured on inland lakes, particularly those of sizes found within SLBE. Such surveys are generally limited to lakes that have recently passed from private to public harvest and/or lakes with special restrictions on access (Patriarche 1960; Westers 1963; Schneider 1973; Clady 1975; Schneider 1995; Schneider 2001). In situations where lakes have been open to the public historically, angler surveys have been useful in monitoring fishery quality following regulatory changes (Schneider and Juetten 1989; Miller 1992). Angling pressure and harvest is not monitored in SLBE lakes. That being said, it would be valuable to begin monitoring, even on a limited basis, harvest and pressure on some SLBE lakes. It is important to note that harvest may be the only influence on fish populations that managers can control within SLBE, particularly given the absence of development impacting the littoral zone of these waterbodies. A particularly important time period of effort and catch that should be monitored is the week largemouth and smallmouth bass open for possession (Saturday before Memorial Day). This period is often when the largest proportion of predators are taken from coolwater systems. These data will help narrow management options and more importantly allow for measuring success of implemented management activities.

Population / Community: As cited in the methods section of this report, the principal focus of the fishery surveys reported in this document was to evaluate species composition of waterbodies in SLBE. To maximize the number of waterbodies surveyed and minimize the potential for undue mortality, we limited the number of nights fished for some lakes and did not employ the use of gillnets in most lakes. Most of the lakes were surveyed in mid-summer when surface temperatures were highest and dissolved oxygen below the thermocline was lowest. Gillnets set in these conditions can result in unnecessary mortality. In many cases, the limited effort by not using gillnets unfortunately resulted in limited catch and may not have provided adequate

samples to thoroughly evaluate community structure and growth of gamefish species. Consequently, it would be advisable that a regular fishery monitoring schedule be established to evaluate the status and trends of SLBE fisheries.

The surveys performed do offer valuable insight to how the lakes are functioning in general, where in many cases growth of gamefish appears to be lower than State average and some of the lakes likely have stunted panfish populations or an overabundance of bullhead. Using these surveys, waterbodies can be prioritized for future management efforts based on their potential for improvement. Based on lake size and depth and history of winterkill, it is clear that some lakes have limited potential for improvements while others have significant potential. Those with higher potential should be further evaluated to develop appropriate management strategies for the benefit of public fisheries. Specific management recommendations were made for each waterbody within SLBE with a general sense of potential. Further discussion is needed on these recommendations and how each lake should be prioritized based on each lake's potential for improvement. Ultimately, management decisions will be made through coordination between the Sleeping Bear Dunes National Lakeshore and the Michigan Department of Natural Resources Fisheries Division. Logically, these decisions should be grounded in the goals and objectives of each agency regarding the provision of fisheries to the public. Understandably, each agency is limited by financial constraints and differing priorities, yet efforts should be made to explore inter-agency collaboration to accomplish fishery goals and objectives.

Exotic species monitoring and management has been referenced repeatedly throughout this document. Due to the potential negative ramifications of inland infestations, it is important that prevention, monitoring, and management activities be given high priority. Further, prudent and effective management of inland fisheries to maintain high biological and ecological integrity and productivity helps these communities cope with infestations if they occur. Zebra mussel and round goby are known to have significant negative impacts on fish and other biological communities, and these impacts are often magnified in smaller inland waters. Implementation of current recommended prevention measures will help reduce the risk of infestation in these waters, but do not effectively deal with situations where infestations have already occurred. Exotic species monitoring should occur annually on waterbodies containing recreational/subsistence fisheries, and consideration should be given to the development of management measures to deal swiftly with detected and imminent infestations. Further discussion regarding management options and strategies should be pursued with local fishery professionals.

Recommended Assessment Schedule

Several factors may govern the frequency and intensity of future fishery surveys conducted within SLBE. Financial limitations are commonly the greatest impedance to conducting timely and effective surveys. From the standpoint of SLBE where fishery staff and equipment are limited or absent, the bulk of any assessment responsibility will lie on the MDNR or other local resource entities, including the Grand Traverse Band. Considering this, assessment of waterbodies should be prioritized, based first on the provision of fisheries to the public, second on financial or logistic constraints, and third on maintaining a current comprehensive fishery inventory within the National Lakeshore. Under this prioritization scheme the following is recommended:

The following lakes and streams with recreational/subsistence fisheries should be surveyed at least every 3-4 years:

School Lake	Shell Lake
Tucker Lake	Bass Lake (Benzie)
Loon Lake	Shalda Creek
Crystal River	Otter Creek
Bass Lake (Leelanau)	Narada Lake
North Bar Lake	Otter Lake
Round Lake	Narada Creek
Platte River	Lake Michigan Sites

Due to financial and logistical constraints the Manitou Island lakes and lakes not within the Park, but adjacent to SLBE properties, could be monitored every 5-7 years. These lakes are:

Lake Manitou	Long Lake (Benzie)
Florence Lake	Rush Lake
Traverse Lake	Little Platte Lake

The following small waterbodies, including ponds, small lakes, and streams not containing recreational or subsistence fisheries, could be surveyed every 7-10 years:

Hatt Pond	Day Mill Pond
Beck Pond	Peterson Rd Ponds
Boekeloo Rd Ponds	Tamarack Lake
Hidden Pond	Taylor Lake
Esch Road Pond	Bow Lakes
Good Harbor Creek	

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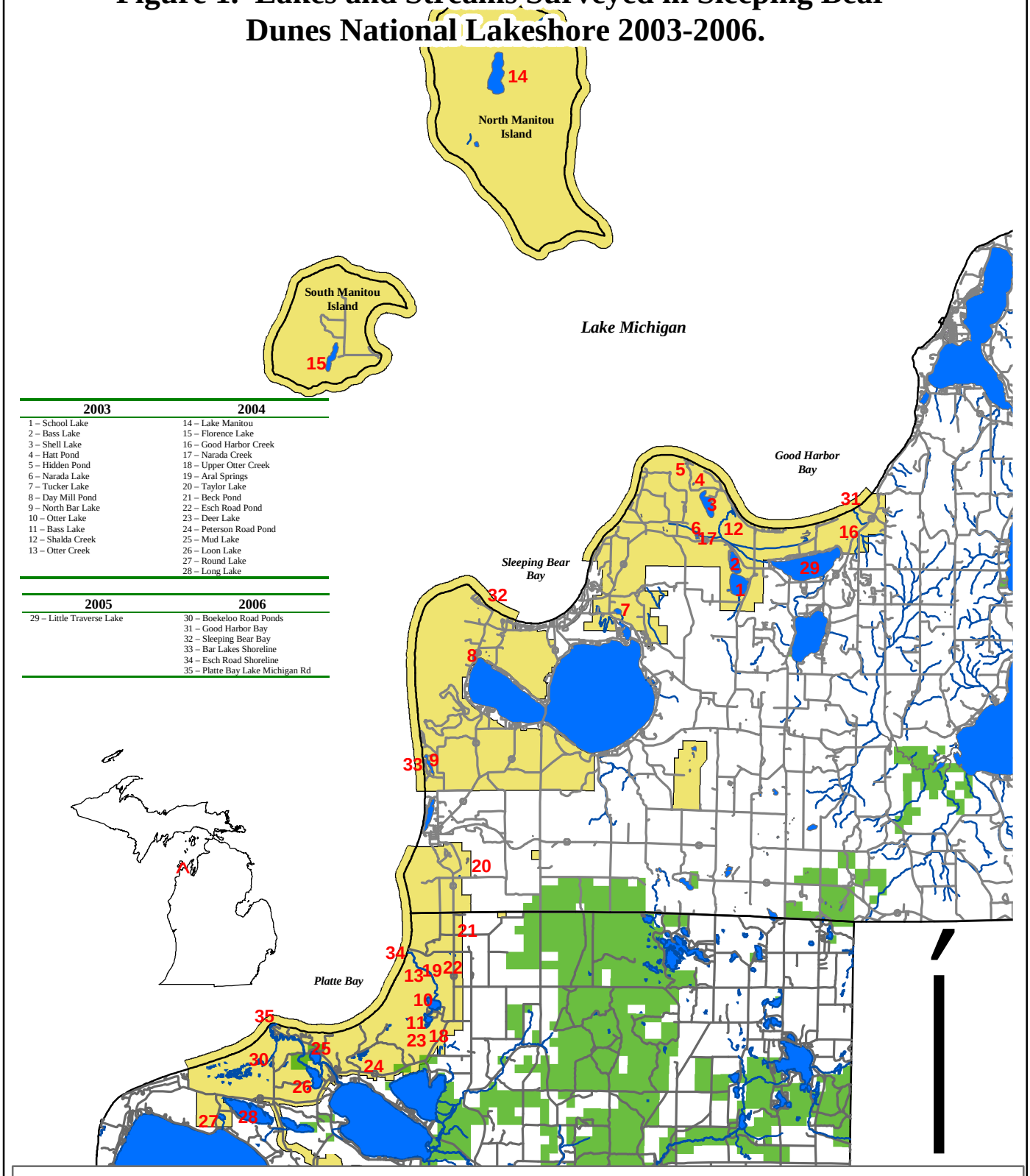
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Figures

Figure 1. Lakes and Streams Surveyed in Sleeping Bear Dunes National Lakeshore 2003-2006.



2003	2004
1 – School Lake	14 – Lake Manitou
2 – Bass Lake	15 – Florence Lake
3 – Shell Lake	16 – Good Harbor Creek
4 – Hatt Pond	17 – Narada Creek
5 – Hidden Pond	18 – Upper Otter Creek
6 – Narada Lake	19 – Aral Springs
7 – Tucker Lake	20 – Taylor Lake
8 – Day Mill Pond	21 – Beck Pond
9 – North Bar Lake	22 – Esch Road Pond
10 – Otter Lake	23 – Deer Lake
11 – Bass Lake	24 – Peterson Road Pond
12 – Shalda Creek	25 – Mud Lake
13 – Otter Creek	26 – Loon Lake
	27 – Round Lake
	28 – Long Lake

2005	2006
29 – Little Traverse Lake	30 – Boekeloo Road Ponds
	31 – Good Harbor Bay
	32 – Sleeping Bear Bay
	33 – Bar Lakes Shoreline
	34 – Esch Road Shoreline
	35 – Platte Bay Lake Michigan Rd

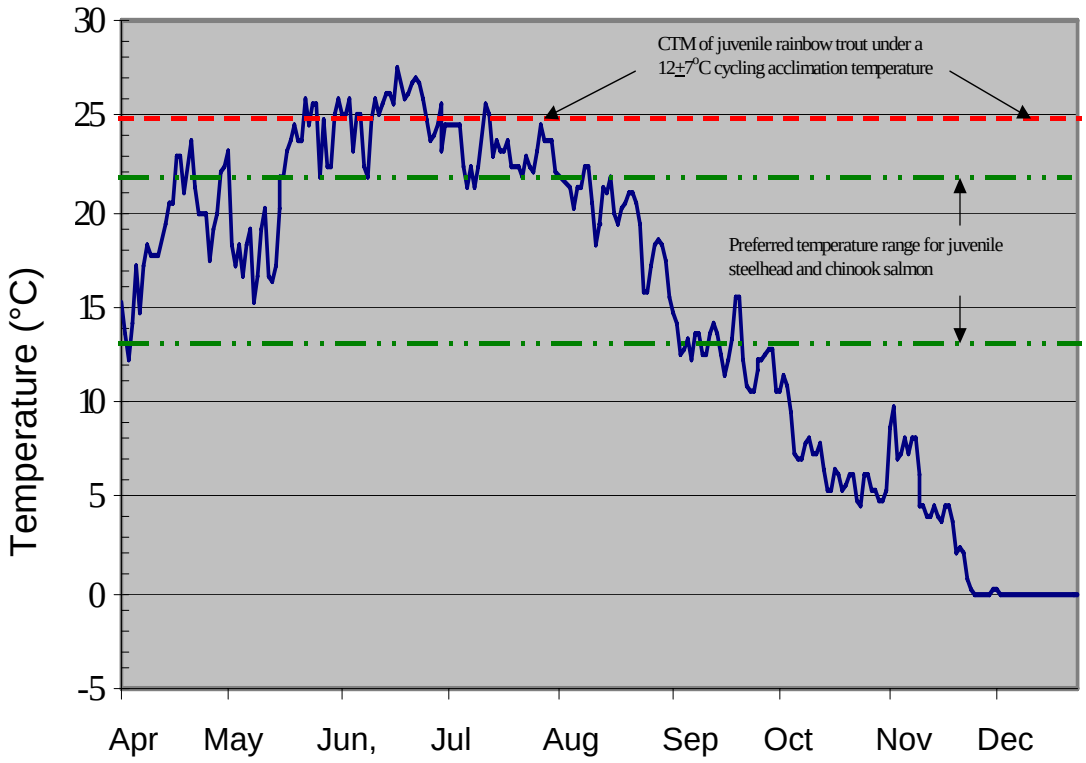
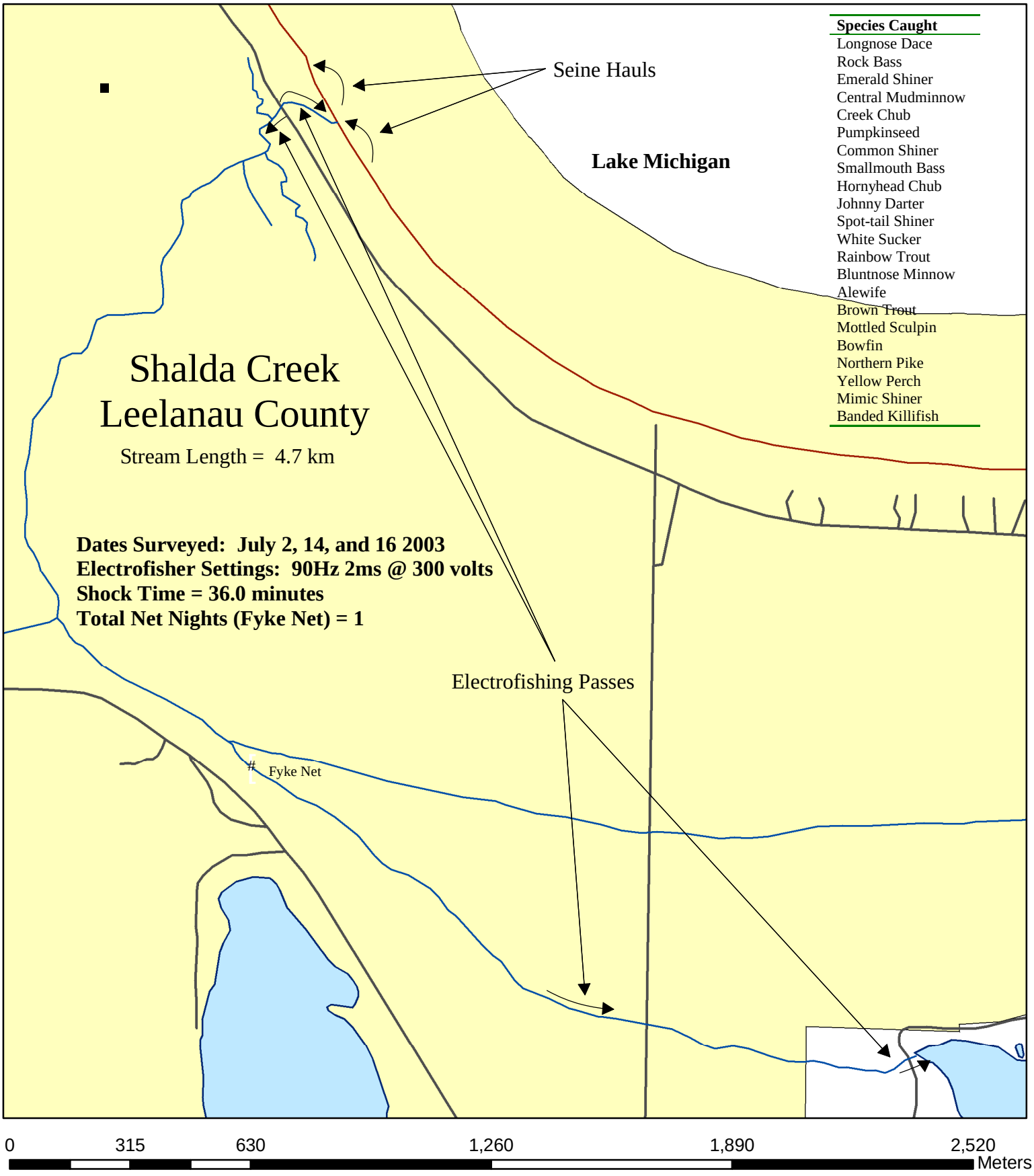


Figure 2.Thermograph of maximum daily temperatures in Shalda Creek, Leelanau County, 1998.



Map Data Source: State of Michigan
Map Prepared By: Grand Traverse Band Ottawa/Chippewa
Map Projection: Michigan GeoReference
June, 2003

Figure 3. Shalda Creek Survey Summary.

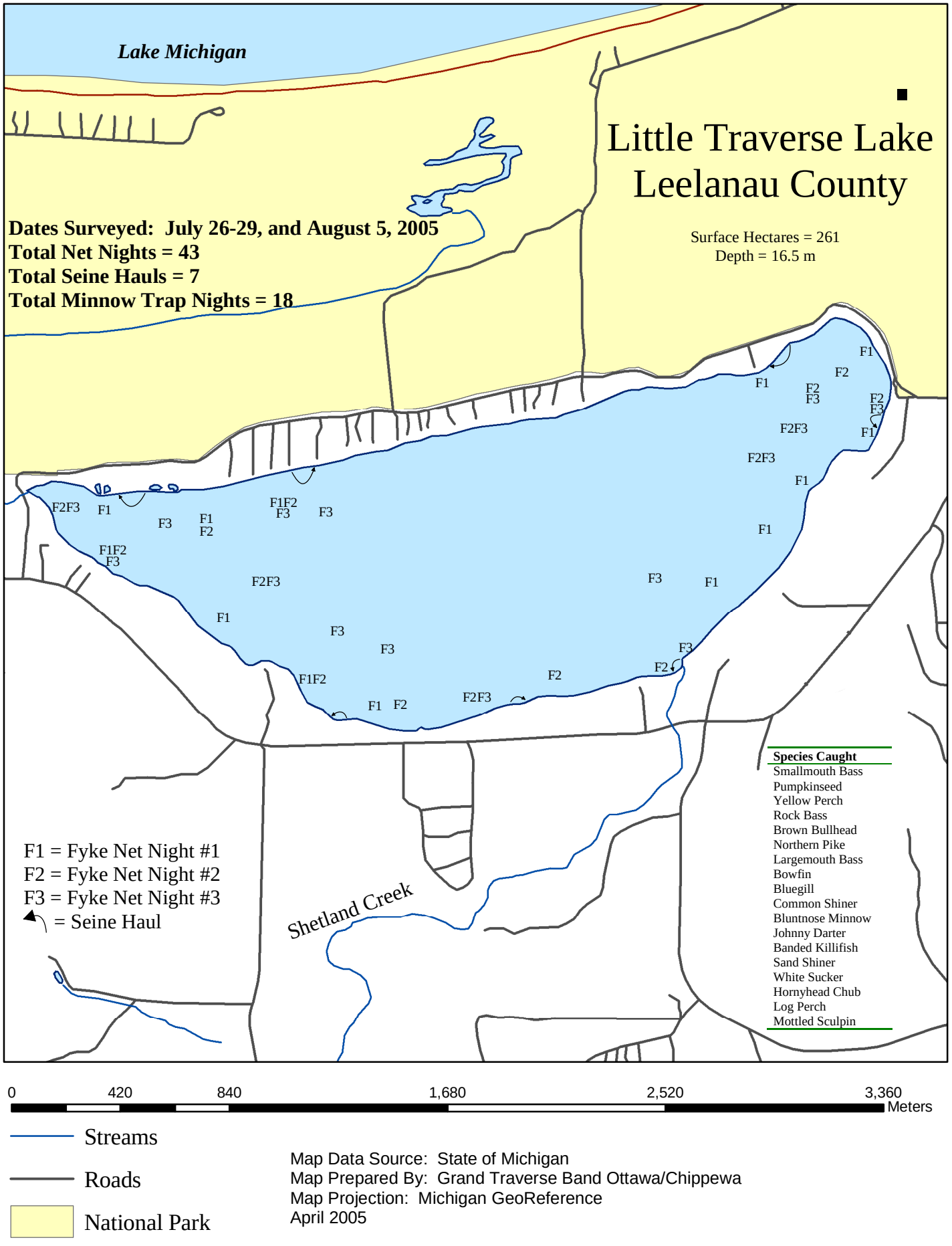
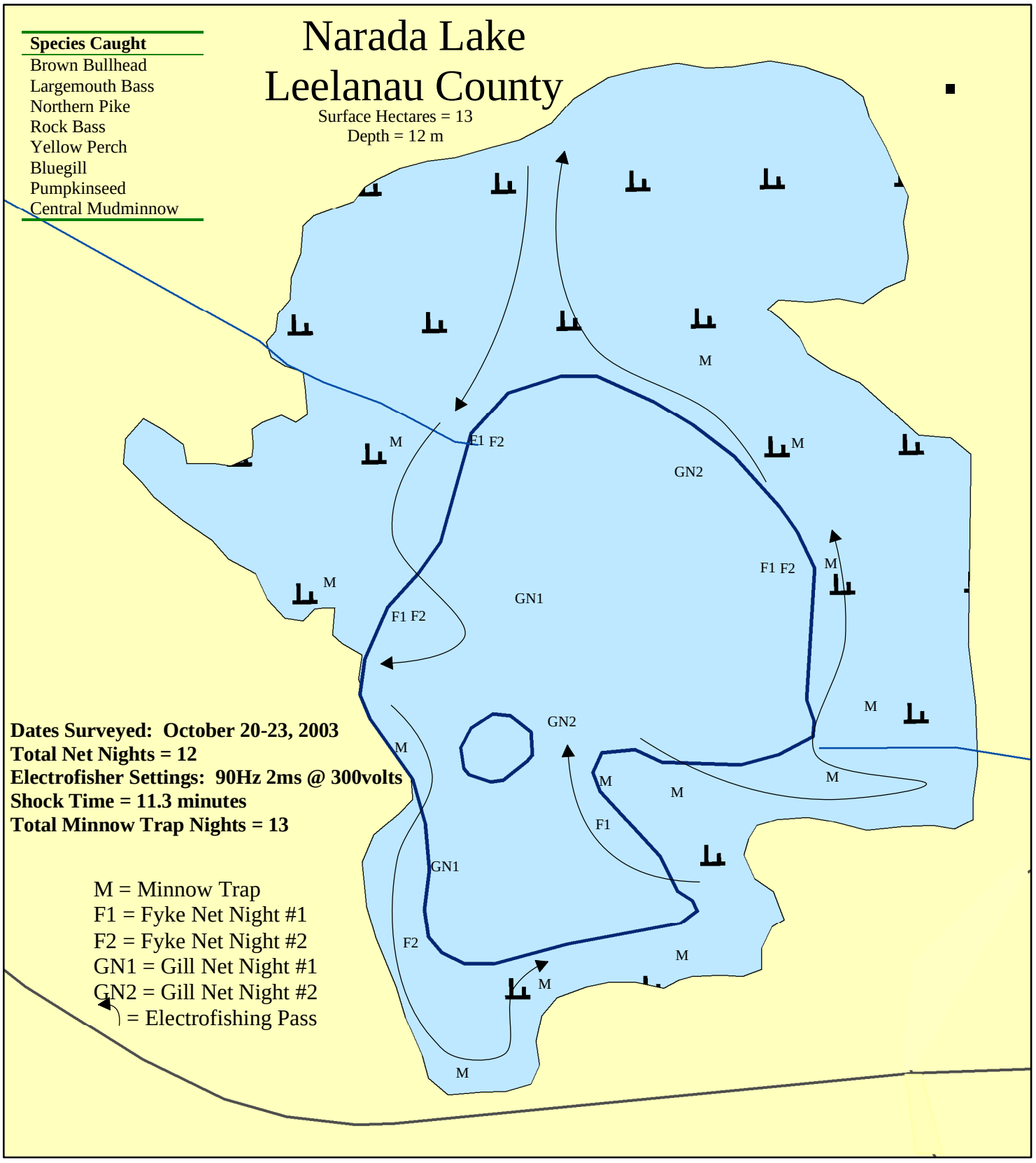


Figure 4. Little Traverse Lake Survey Summary.



Map Data Source: State of Michigan
Map Prepared By: Grand Traverse Band Ottawa/Chippewa
Map Projection: Michigan GeoReference
June, 2003

Figure 5. Narada Lake Survey Summary.

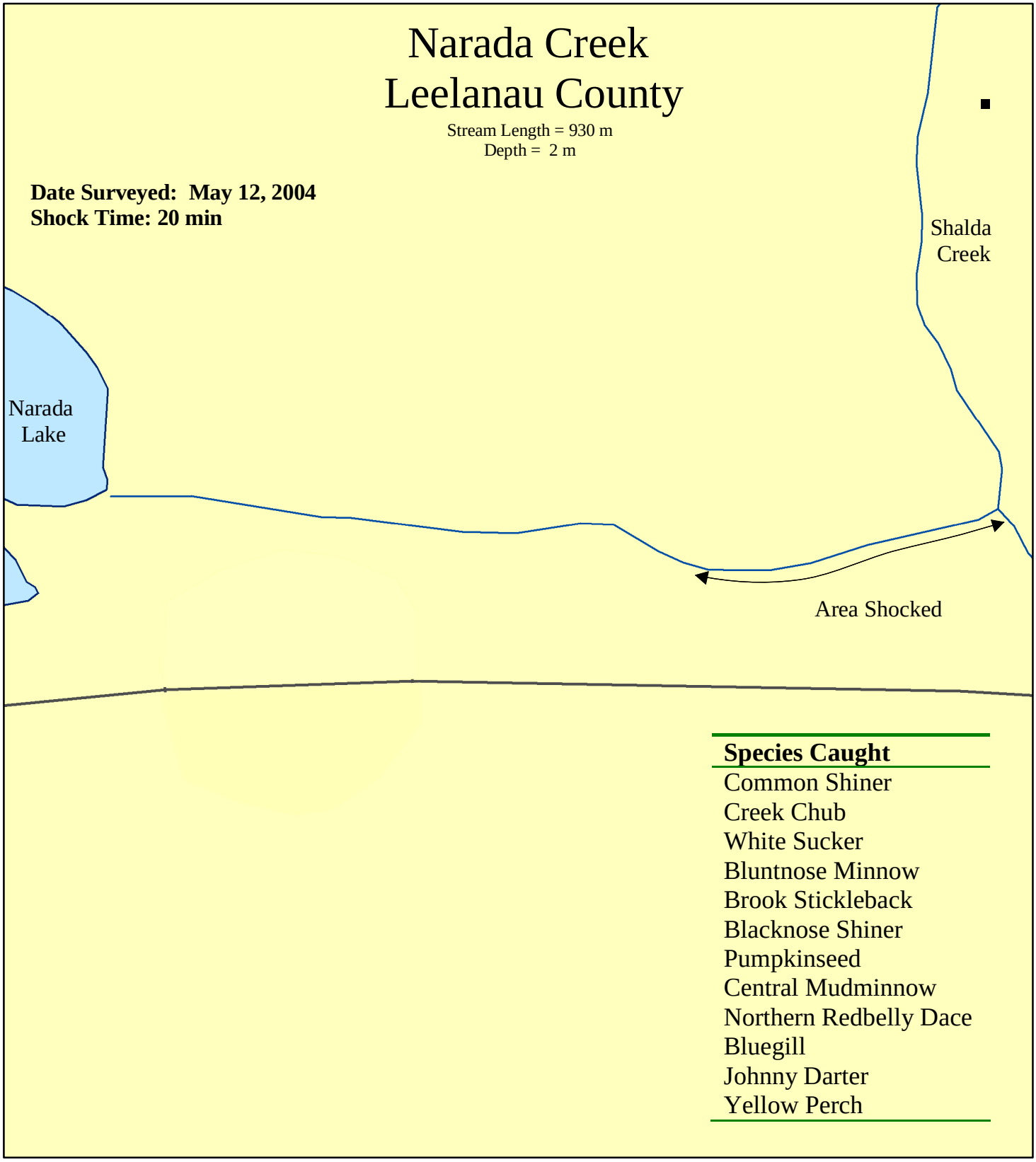


Figure 6. Narada Creek Survey Summary.

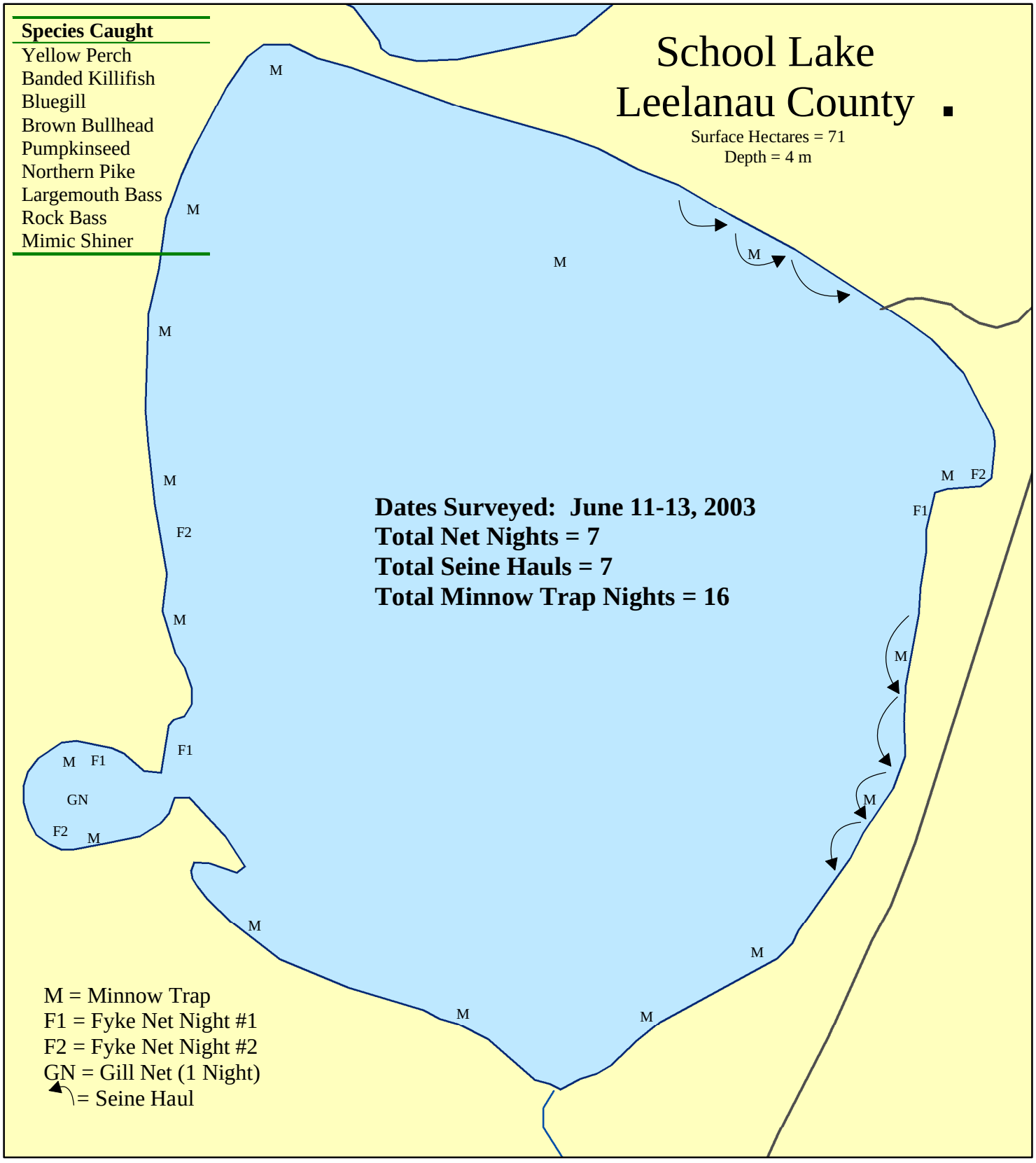


Figure 7. School Lake Survey Summary.

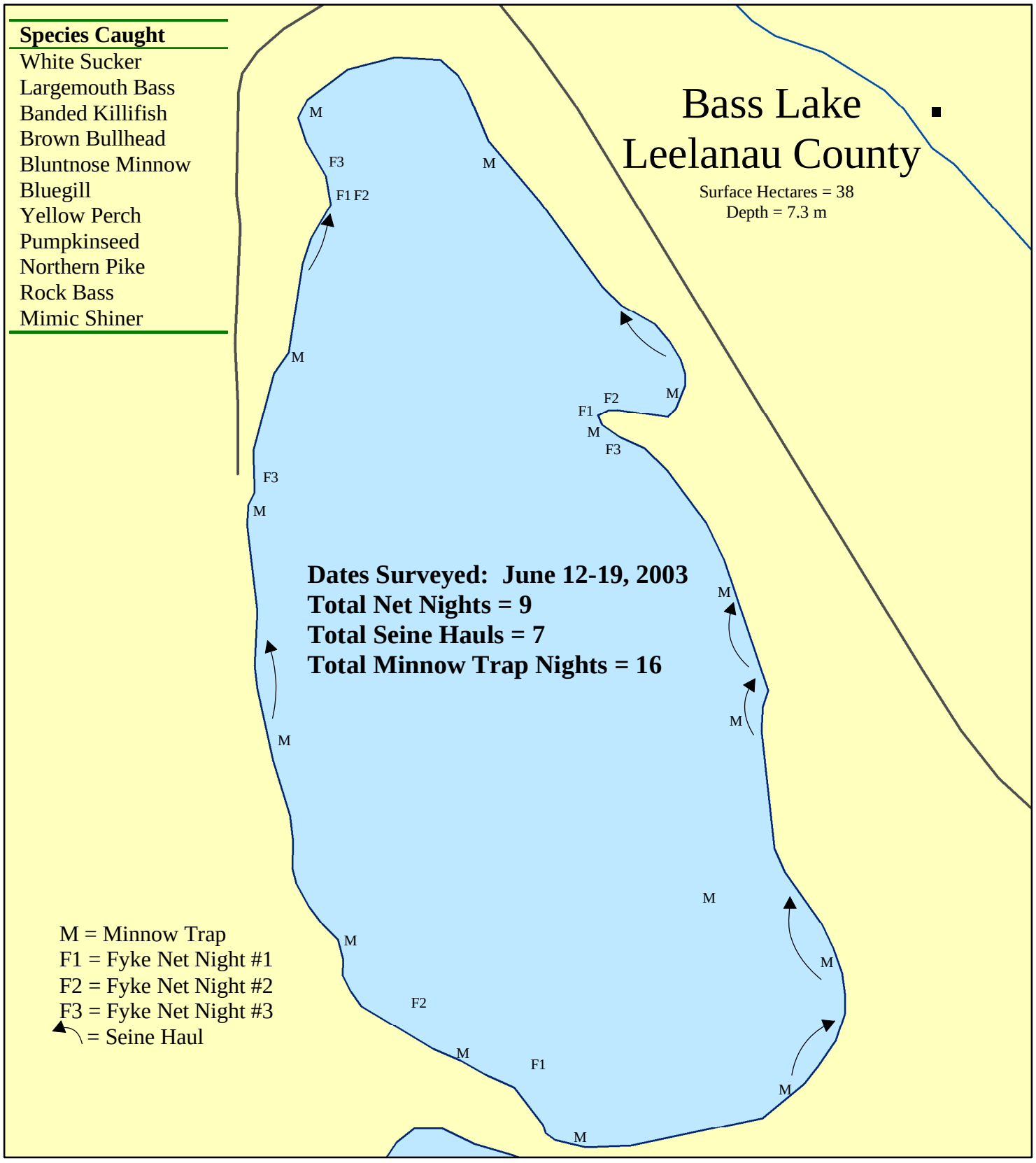


Figure 8. Bass Lake Leelanau County Survey Summary.

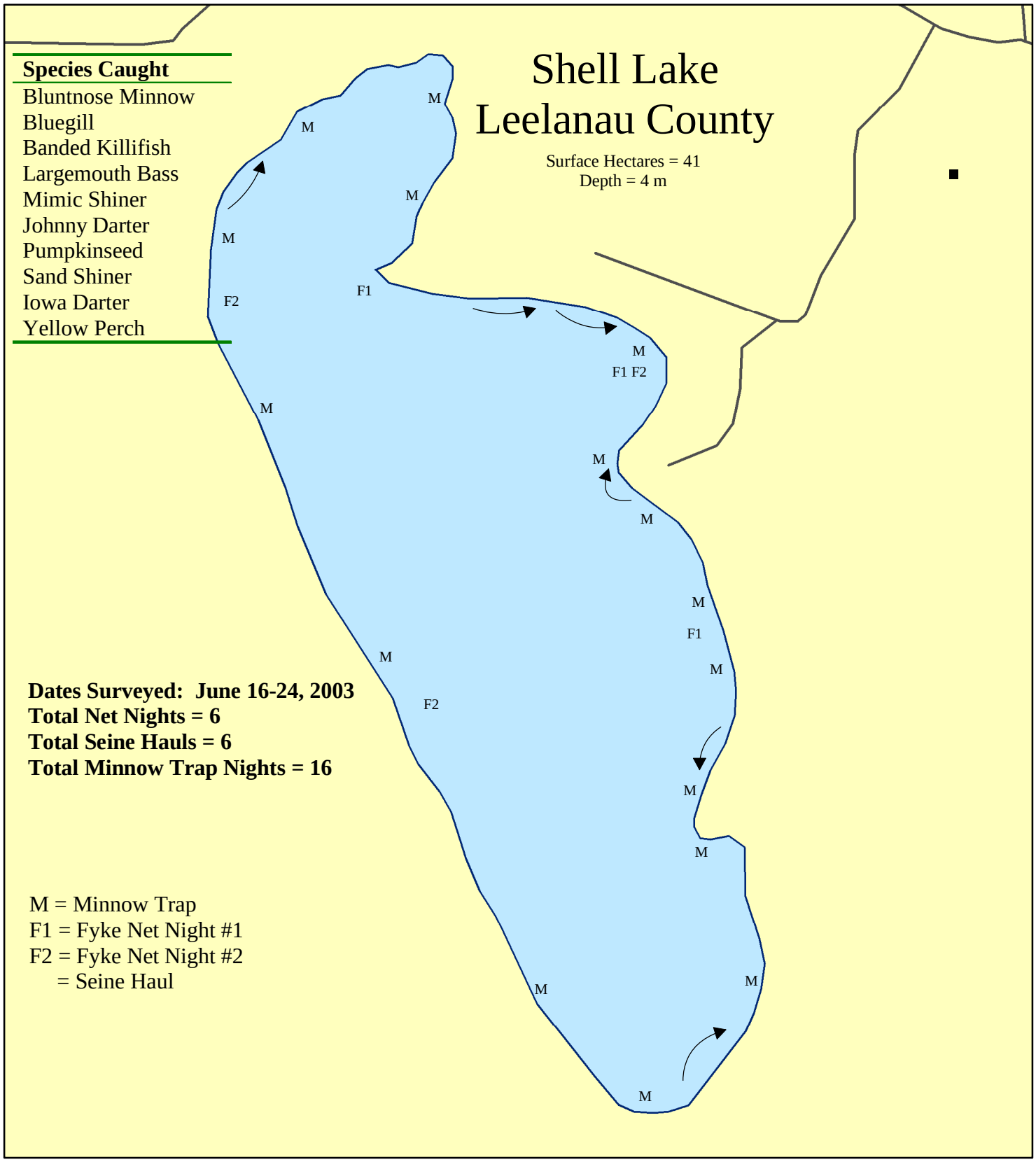


Figure 9. Shell Lake Survey Summary.

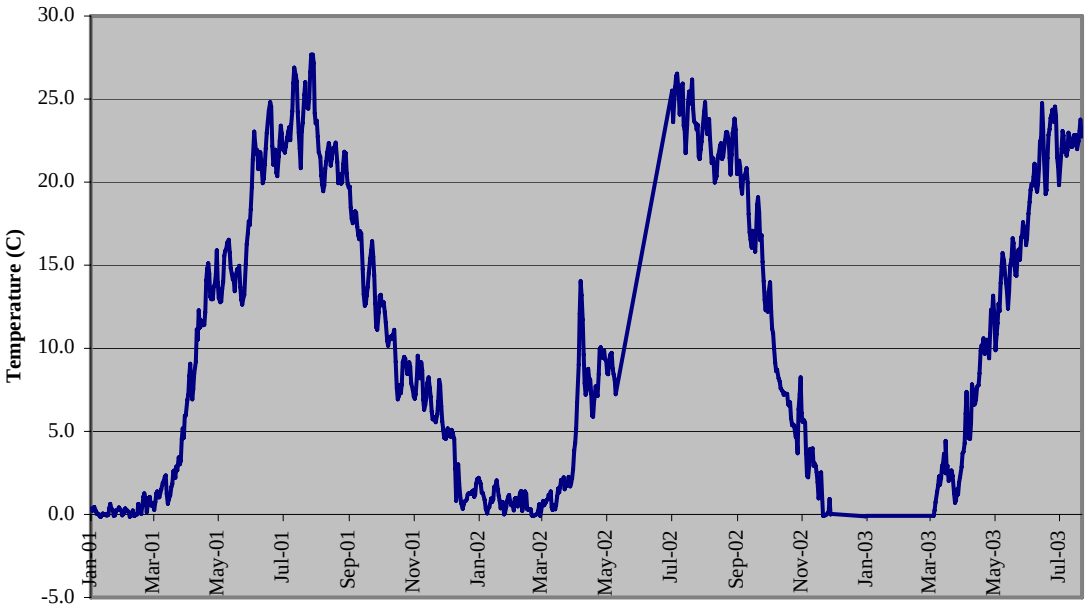


Figure 10. Crystal River Average Daily Temperatures 2001-2003.

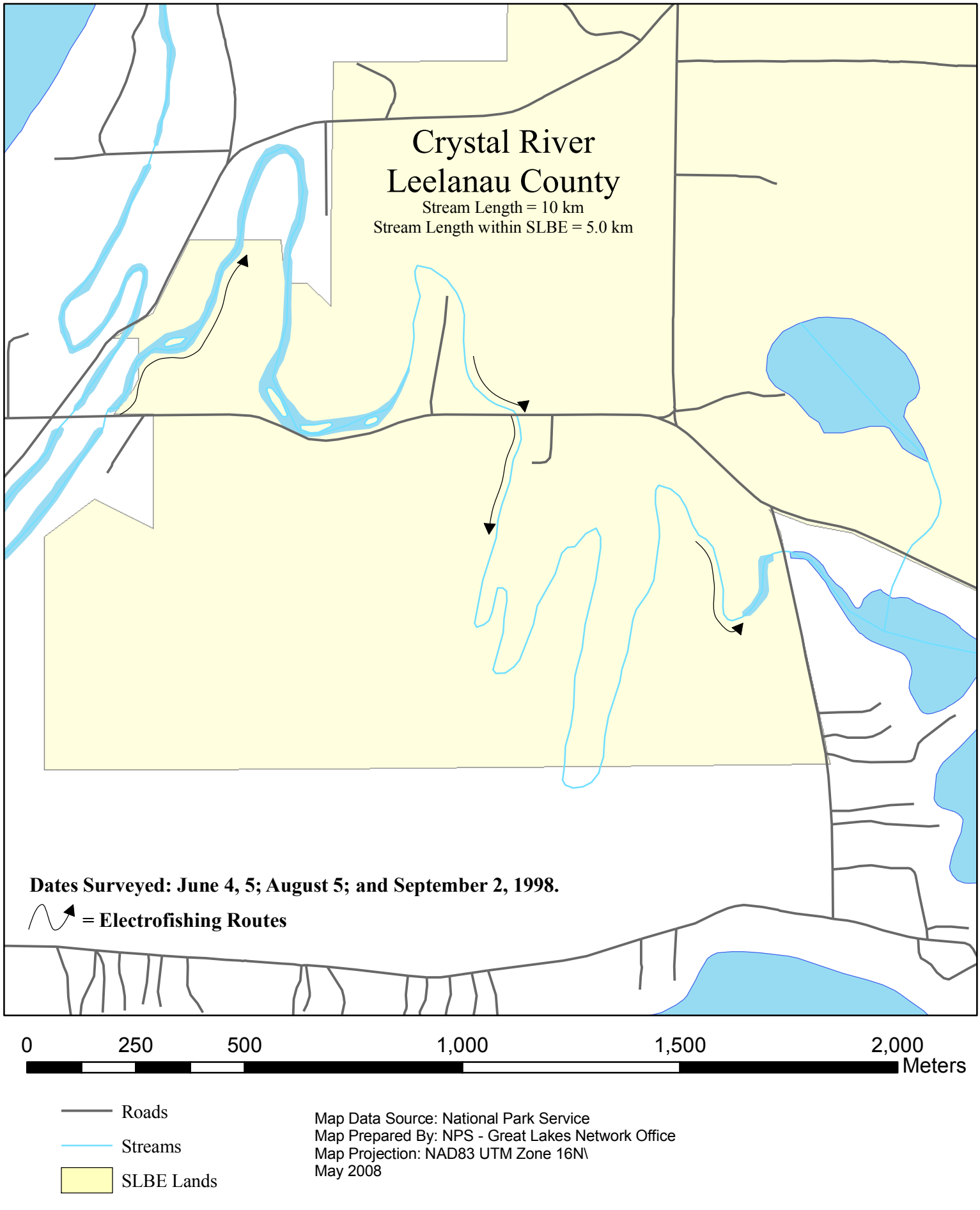


Figure 11. Crystal River Survey Summary

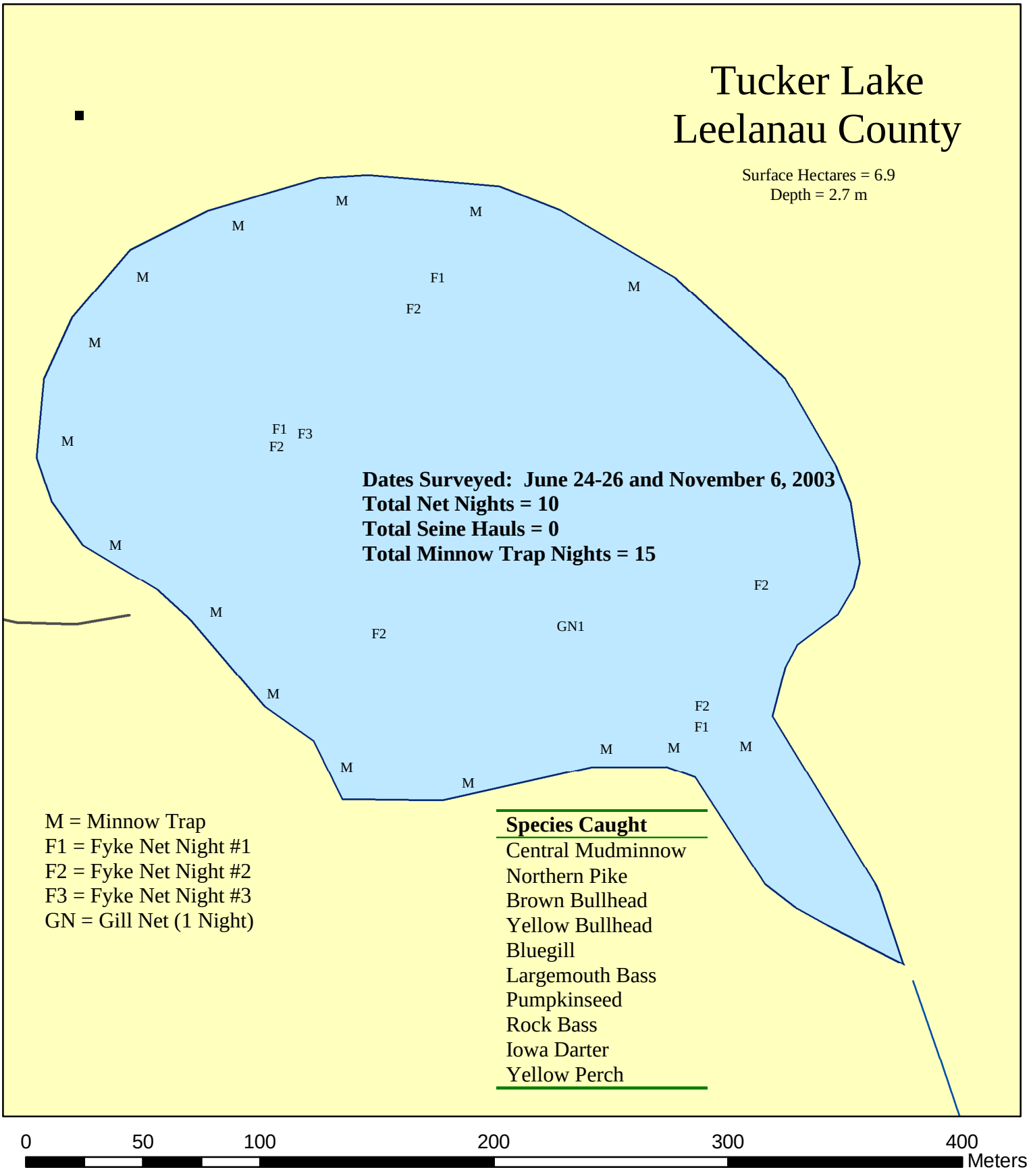


Figure 12. Tucker Lake Survey Summary.

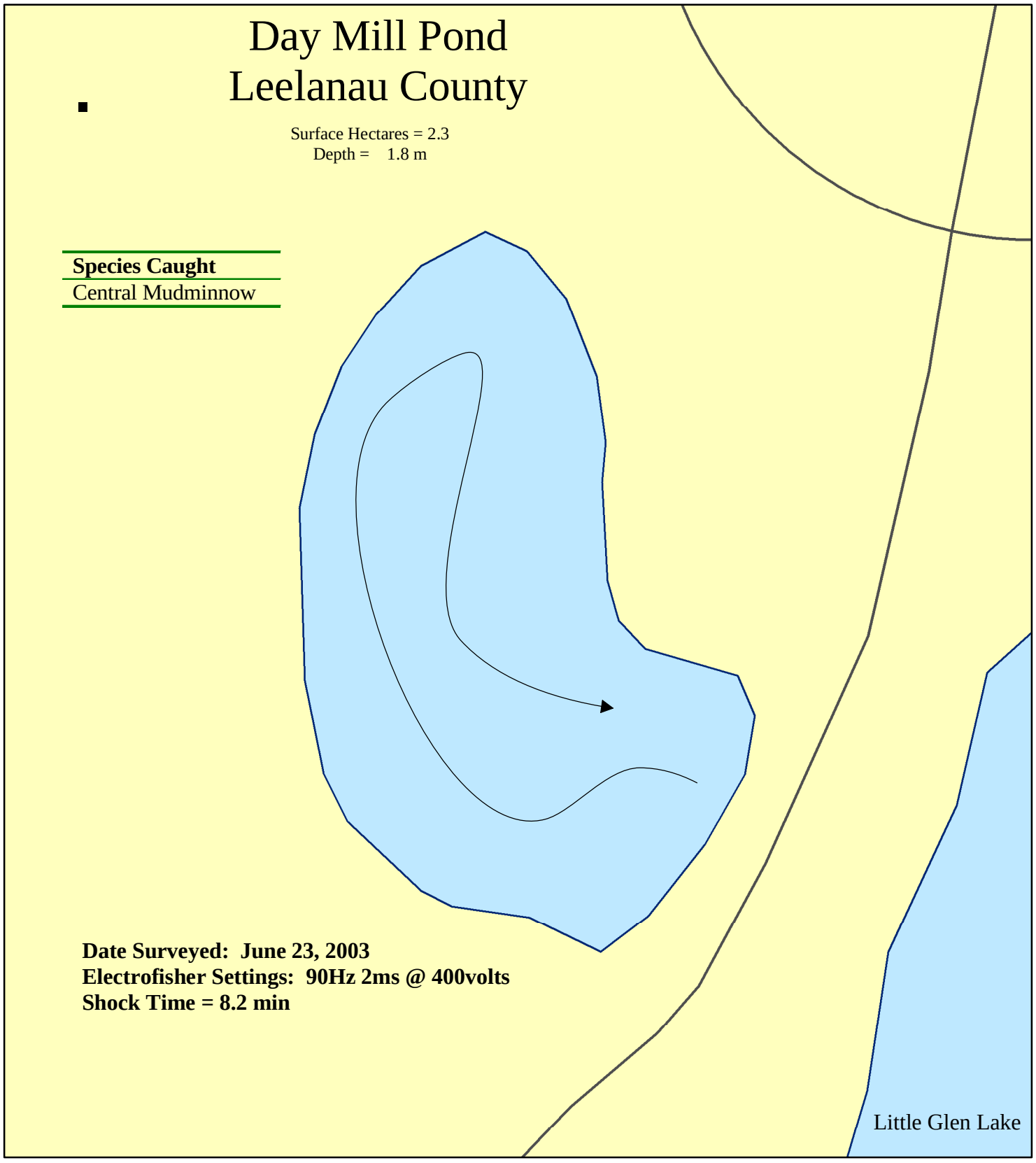


Figure 13. Day Mill Pond Survey Summary.

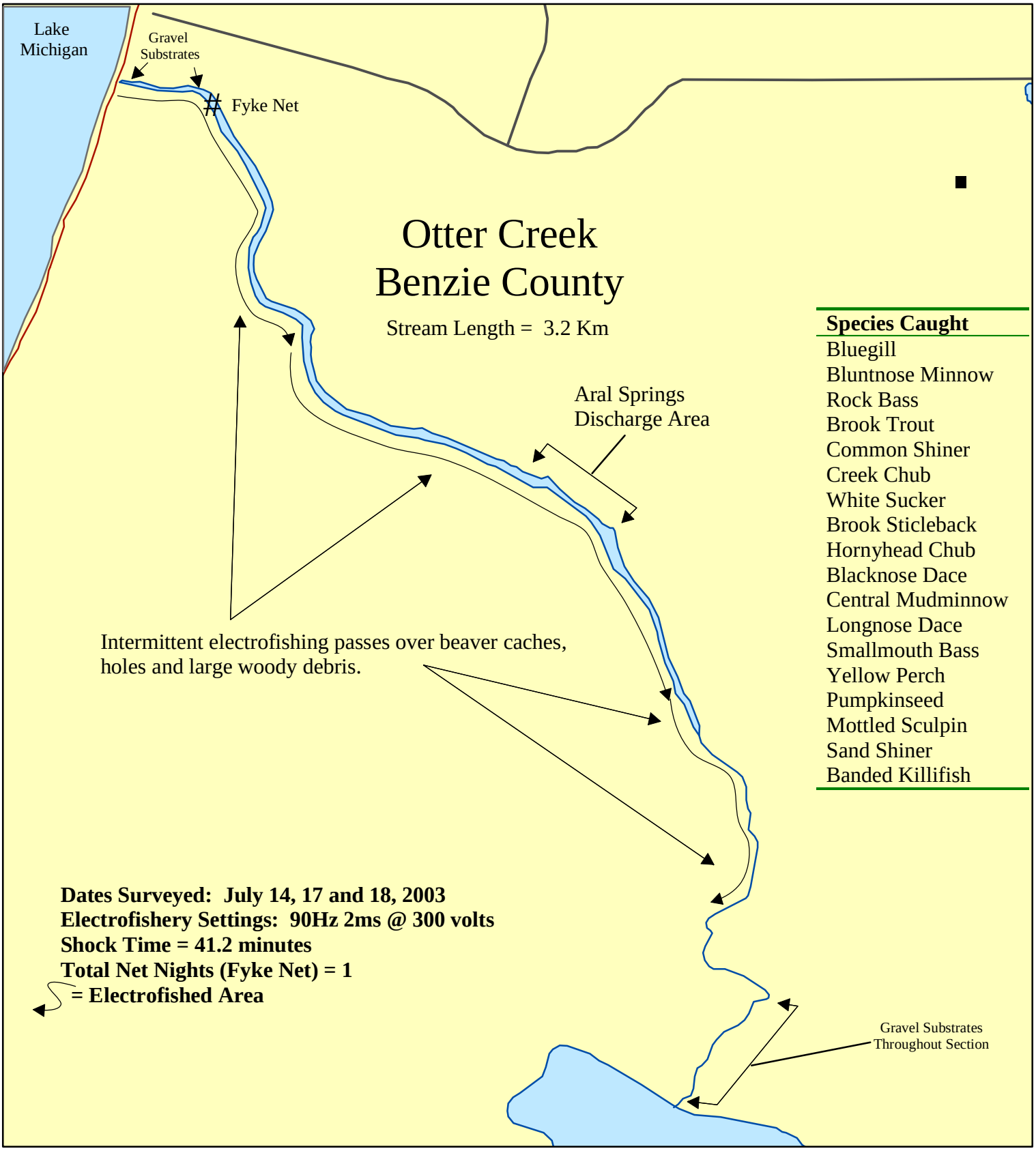


Figure 14. Otter Creek Survey Summary.

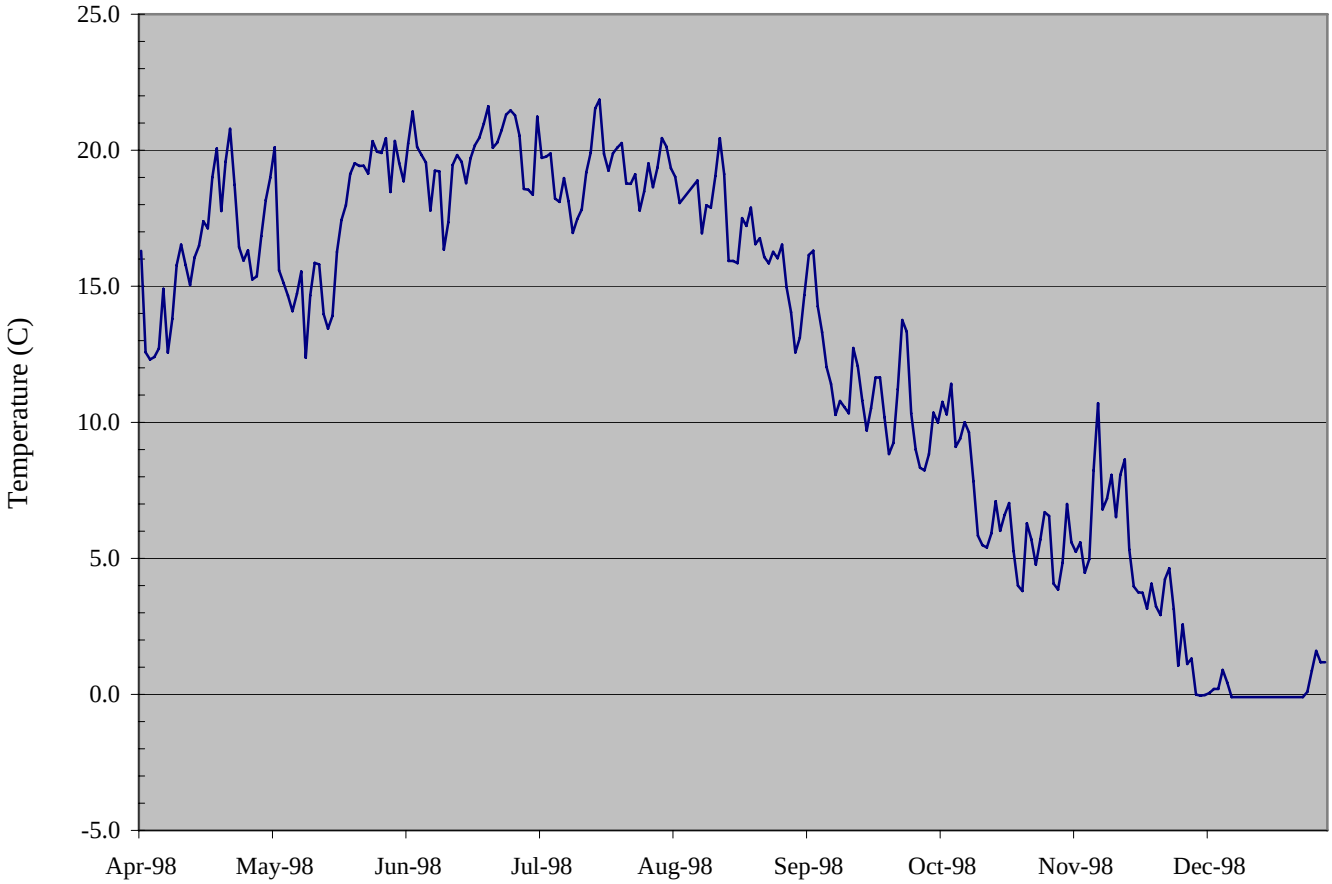


Figure 15. Thermograph of average daily temperatures, Otter Creek, Benzie County, 1998.

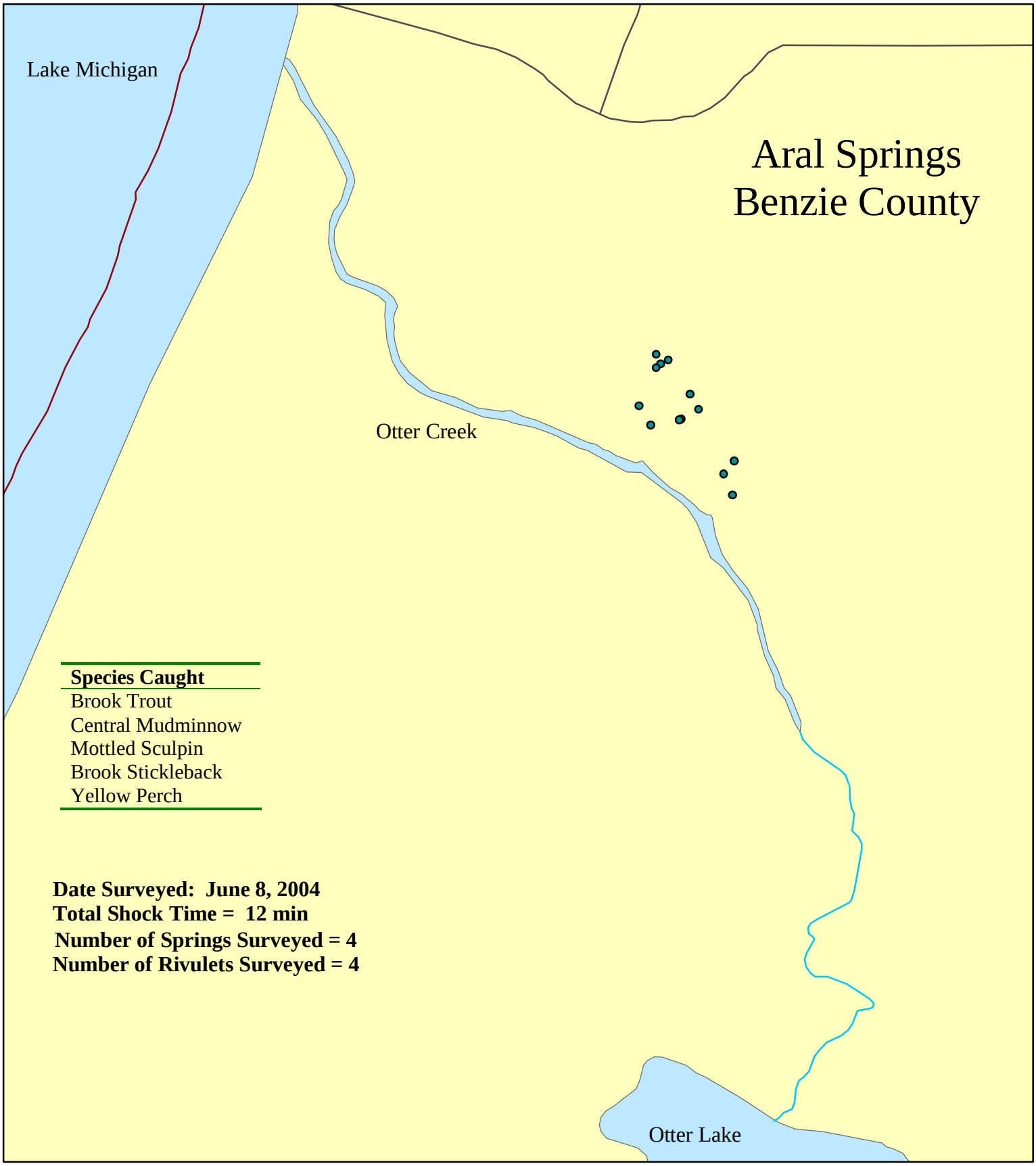


Figure 16. Aral Springs Survey Summary.

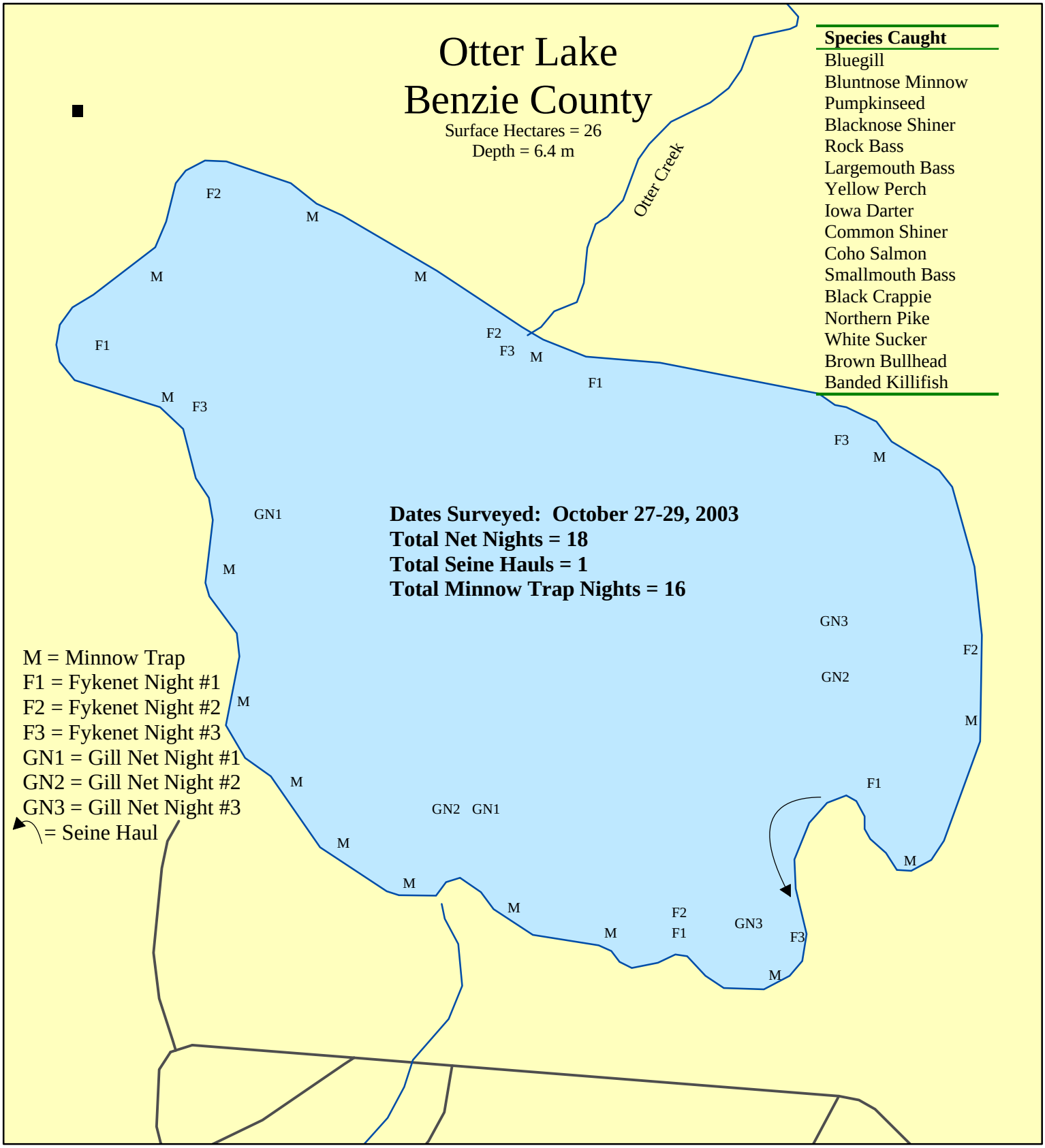


Figure 17. Otter Lake Survey Summary.

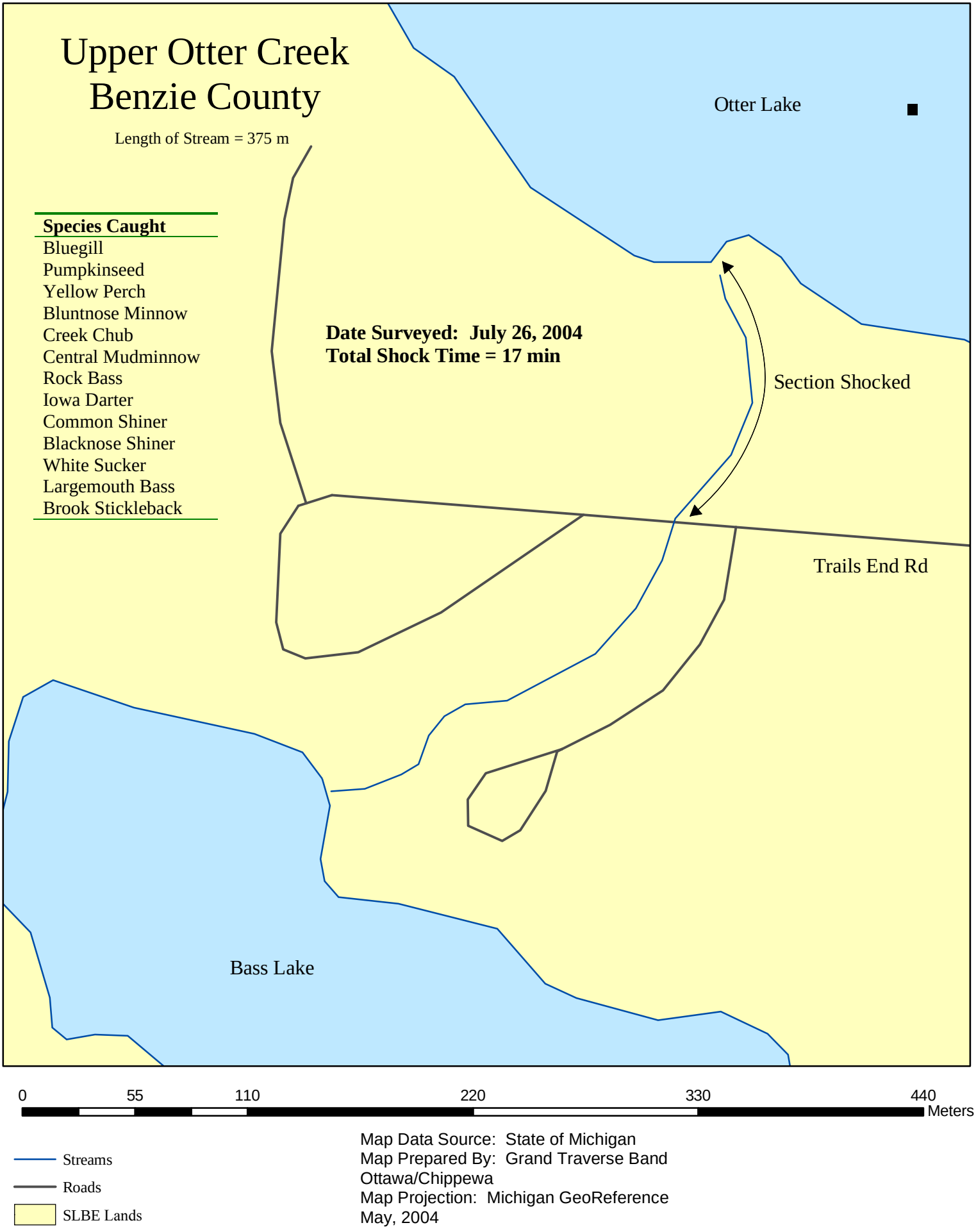


Figure 18. Upper Otter Creek Survey Summary.

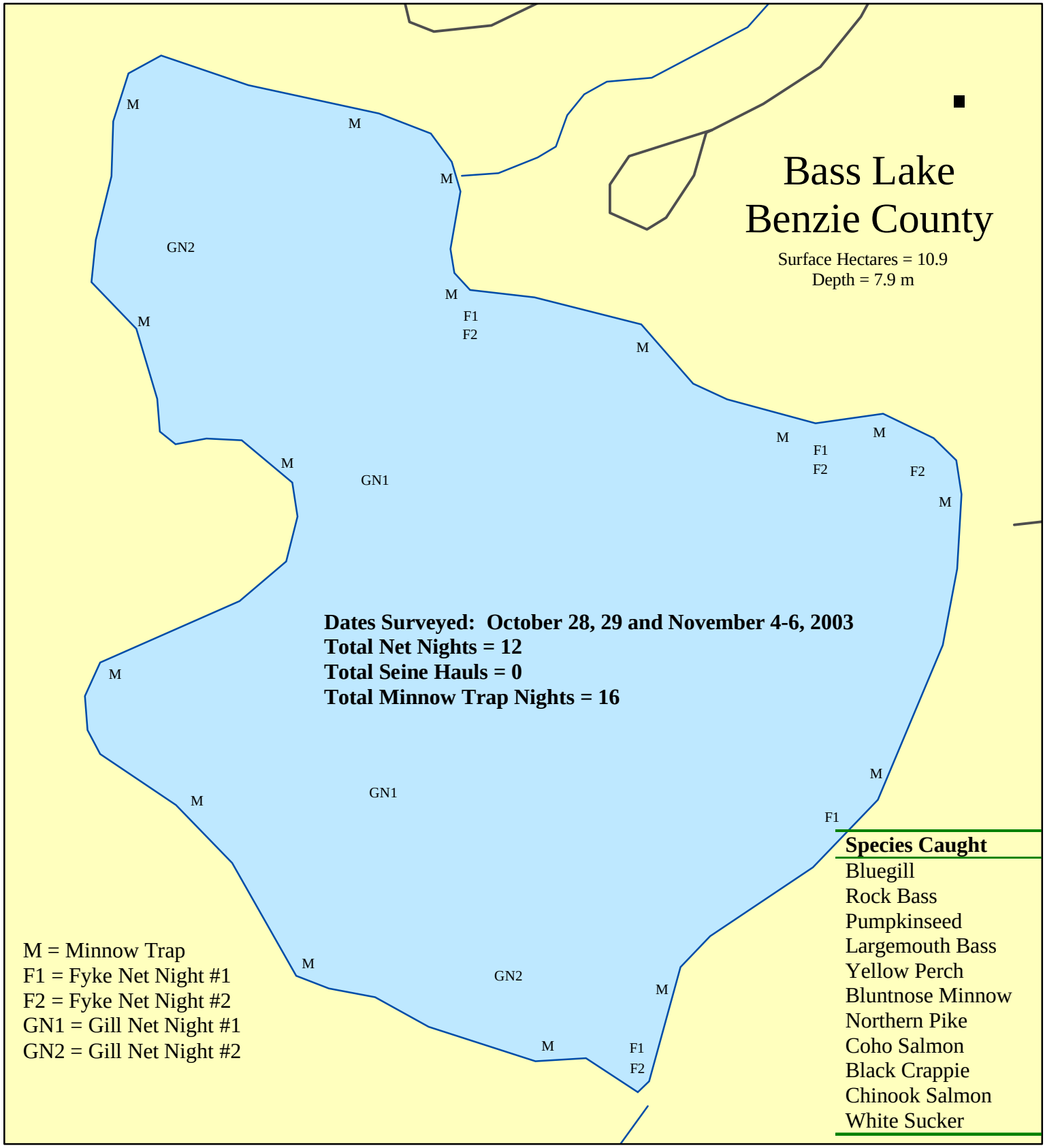


Figure 19. Bass Lake Benzie County Survey Summary.

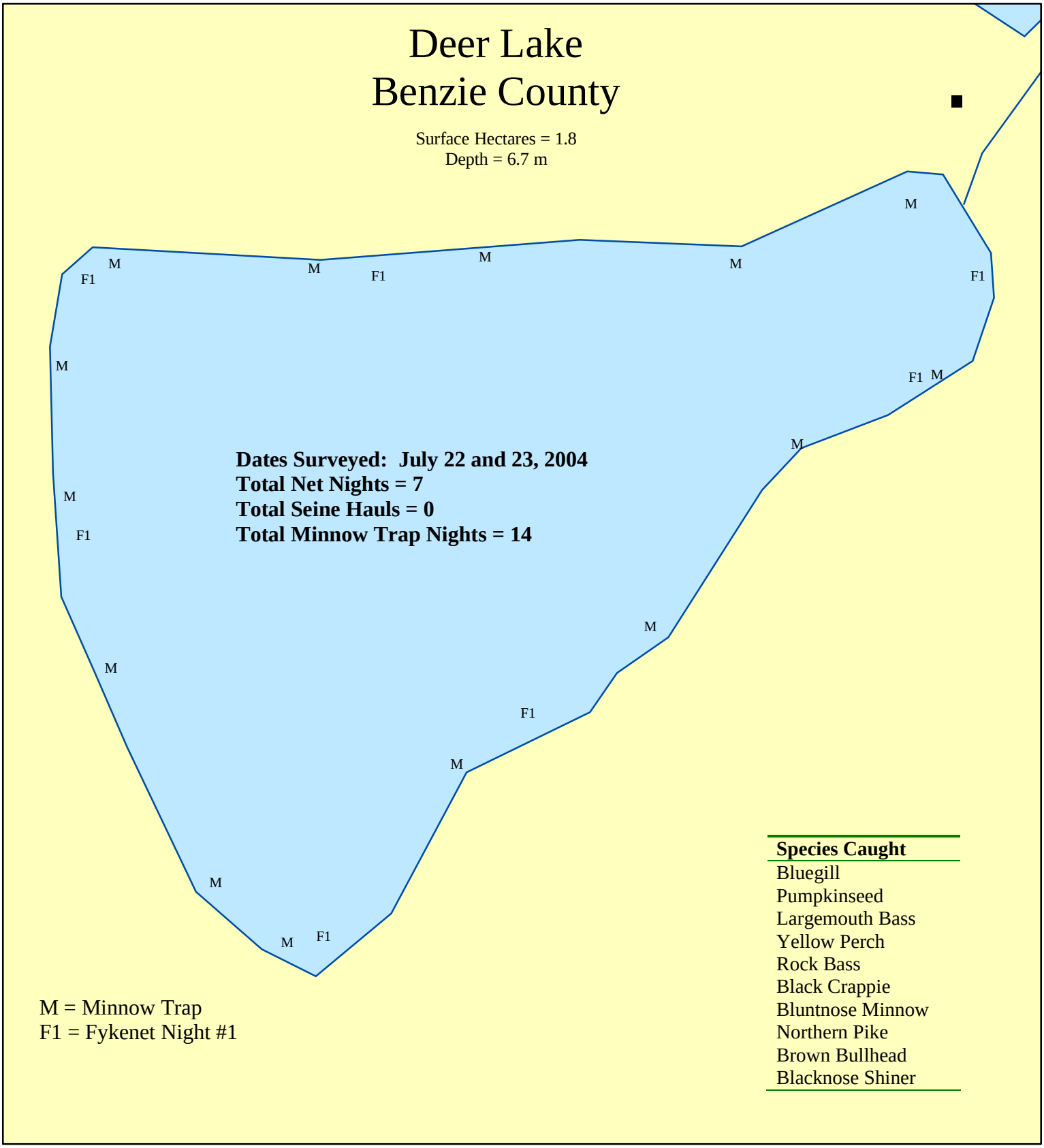


Figure 20. Deer Lake Survey Summary.

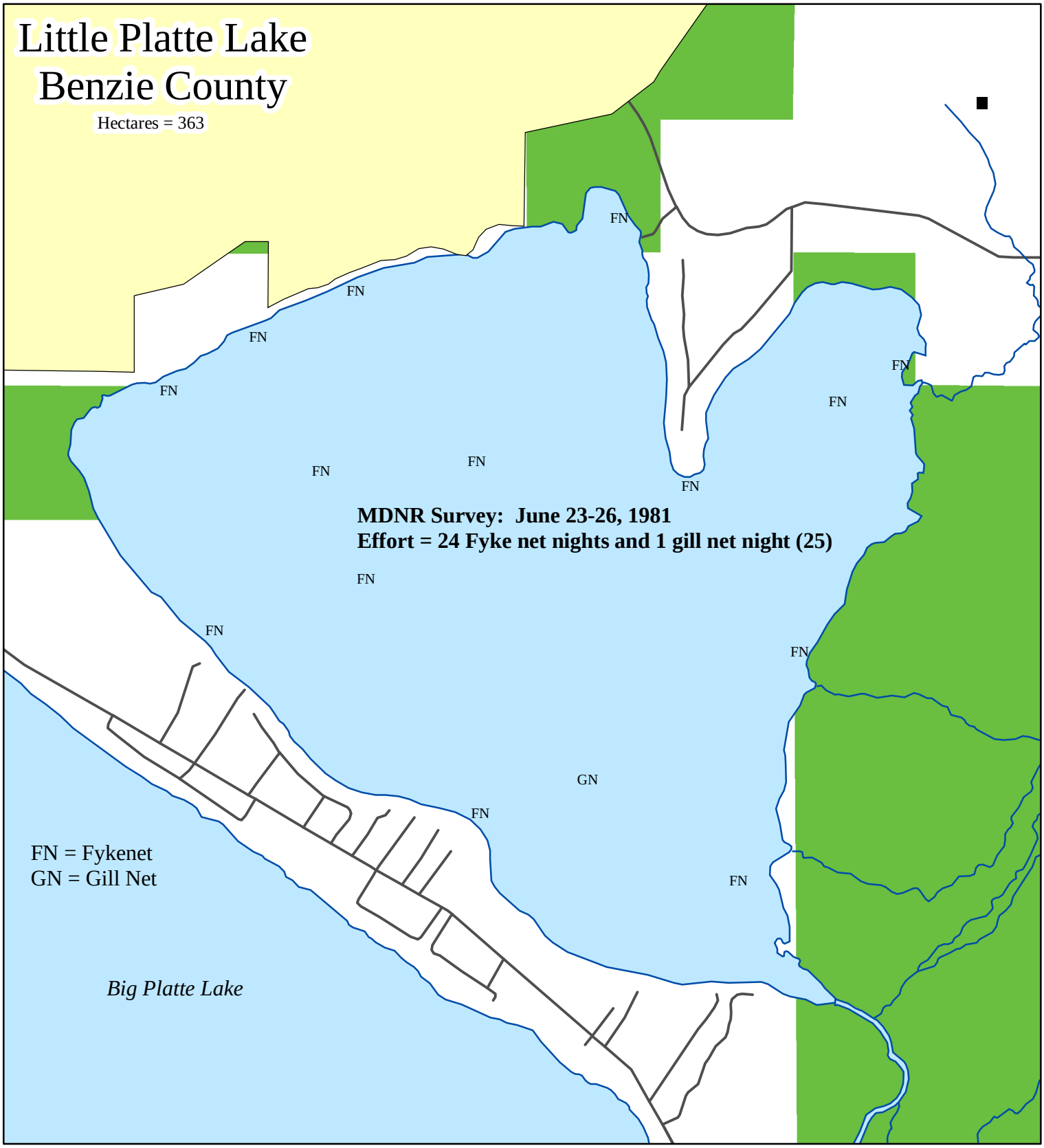
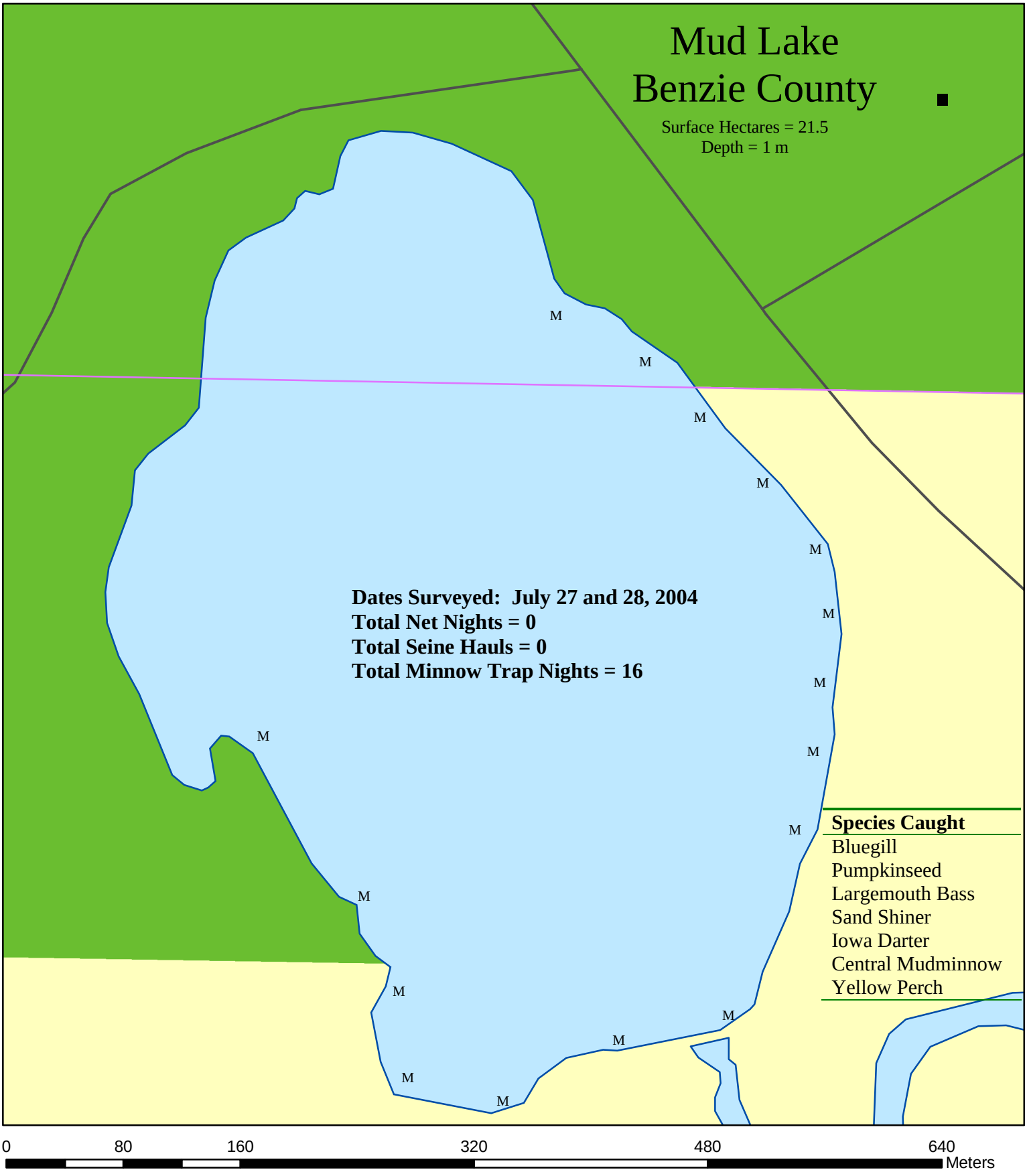
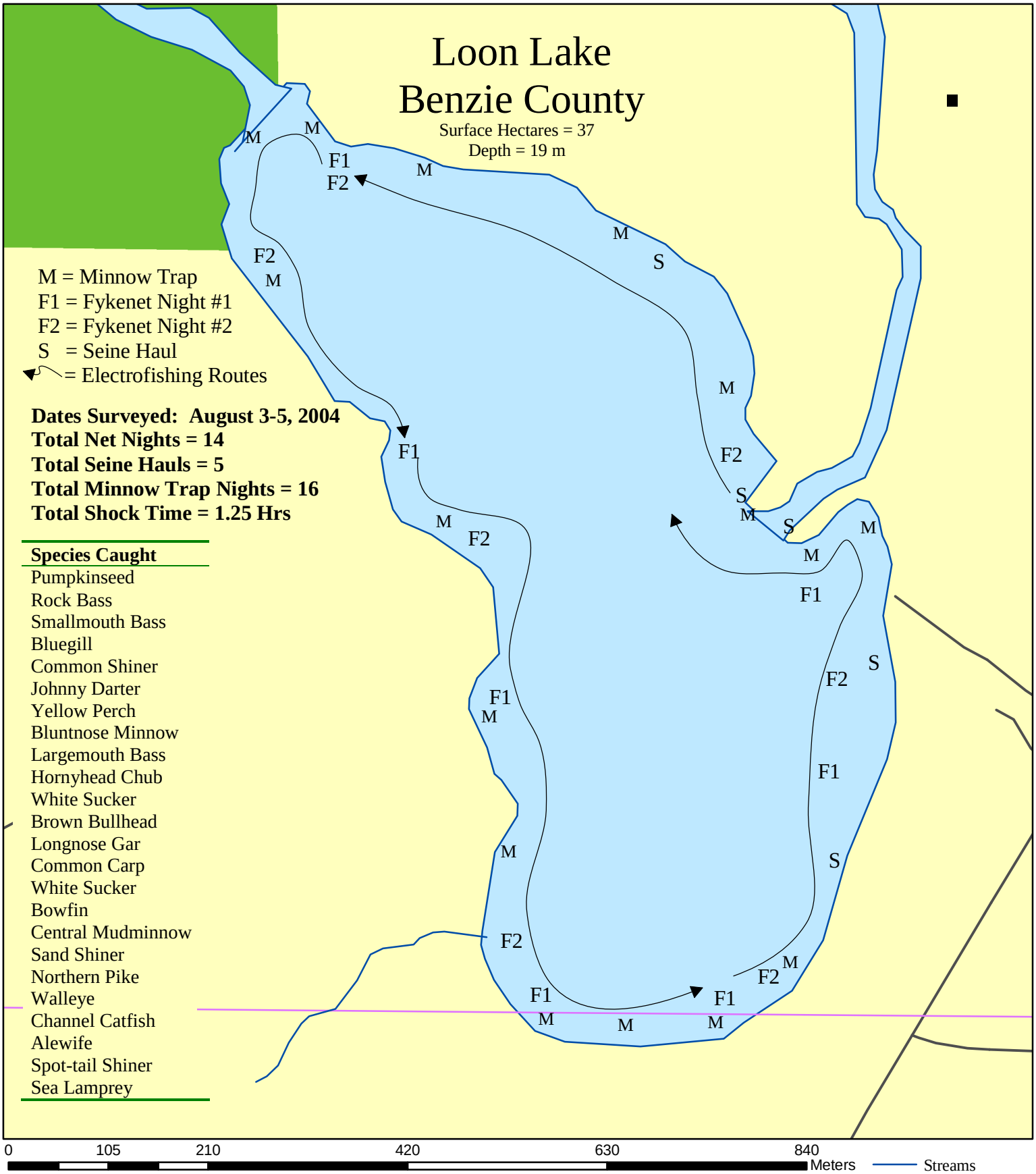


Figure 21. Little Platte Lake Survey Summary.



Map Data Source: State of Michigan
Map Prepared By: Grand Traverse Band Ottawa/Chippewa
Map Projection: Michigan GeoReference
July 2005

Figure 22. Mud Lake Survey Summary.



Map Data Source: State of Michigan
Map Prepared By: Grand Traverse Band Ottawa/Chippewa
Map Projection: Michigan GeoReference
June, 2003

Figure 23. Loon Lake Survey Summary.

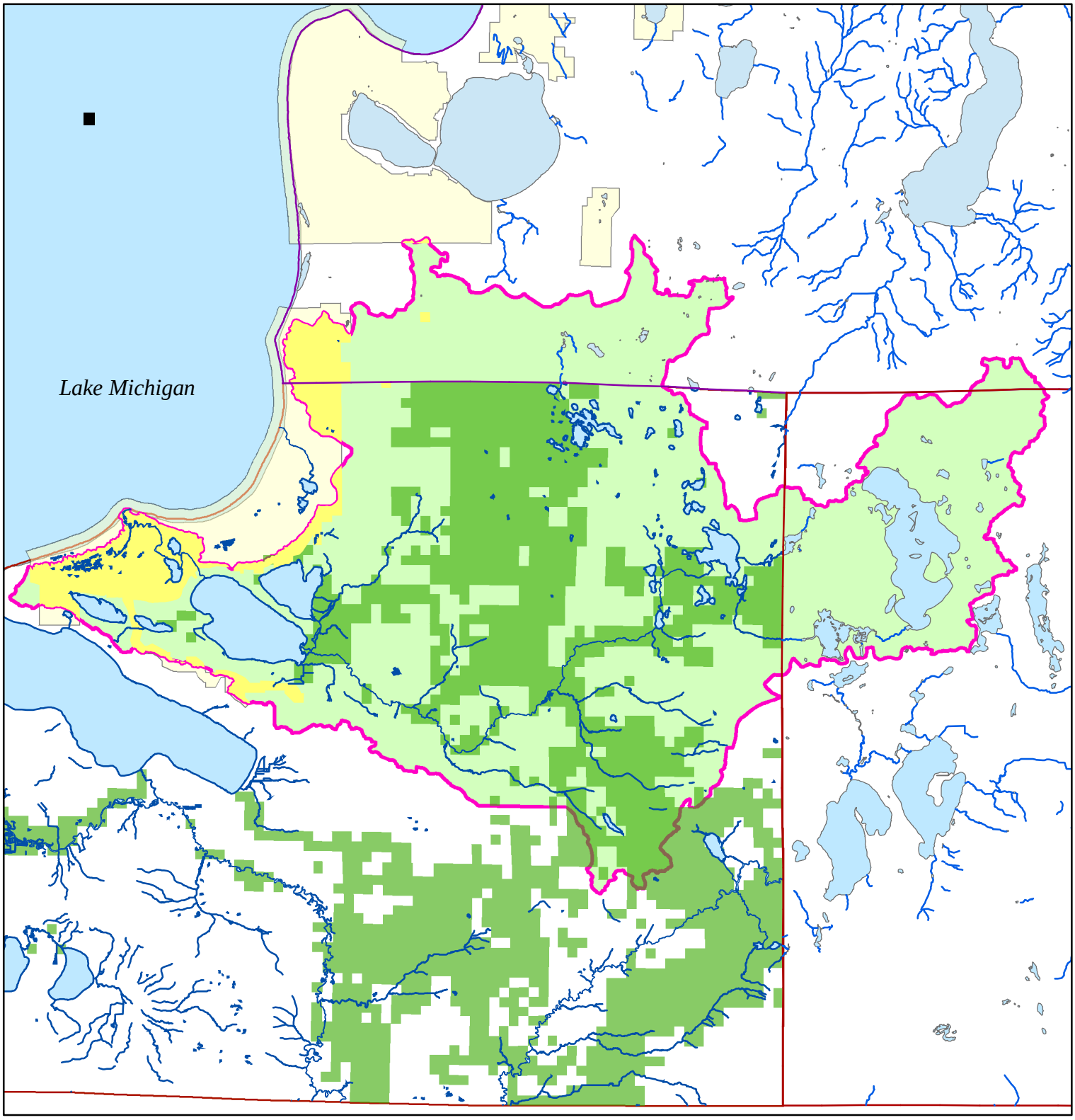


Figure 24. Platte River Watershed within SLBE.

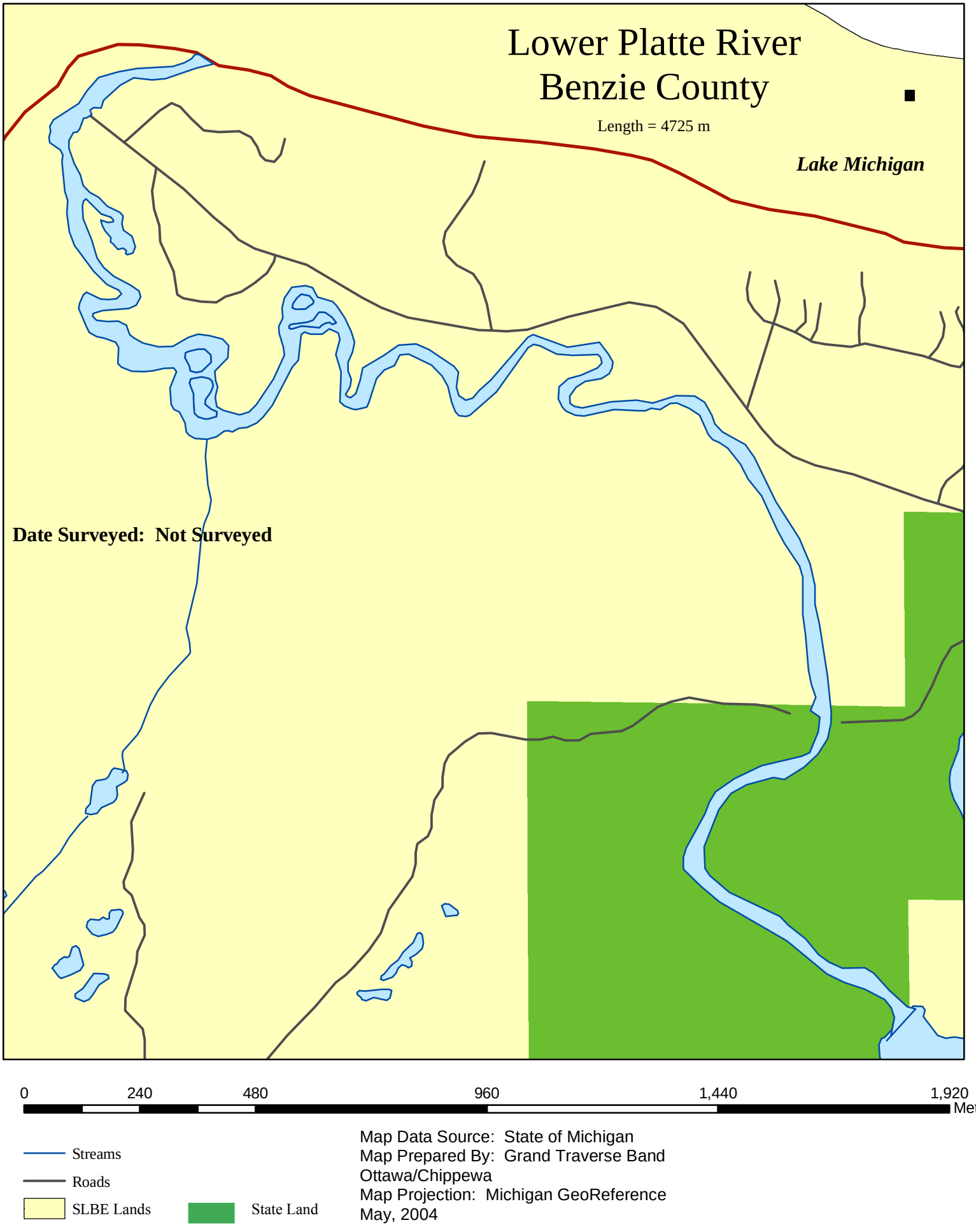
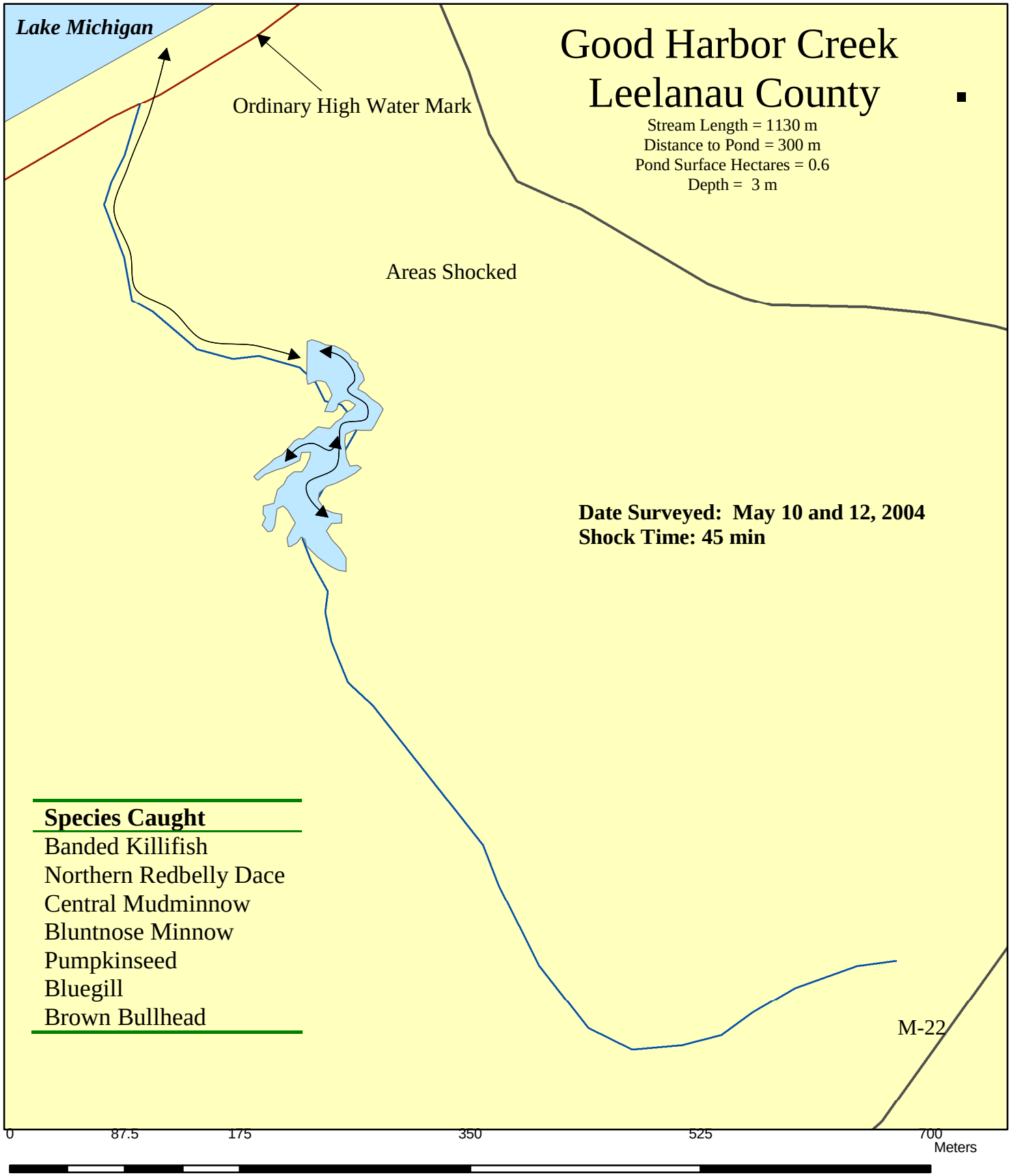


Figure 25. Lower Platte River Survey Summary.



Map Data Source: State of Michigan
Map Prepared By: Grand Traverse Band Ottawa/Chippewa
Map Projection: Michigan GeoReference
May, 2004

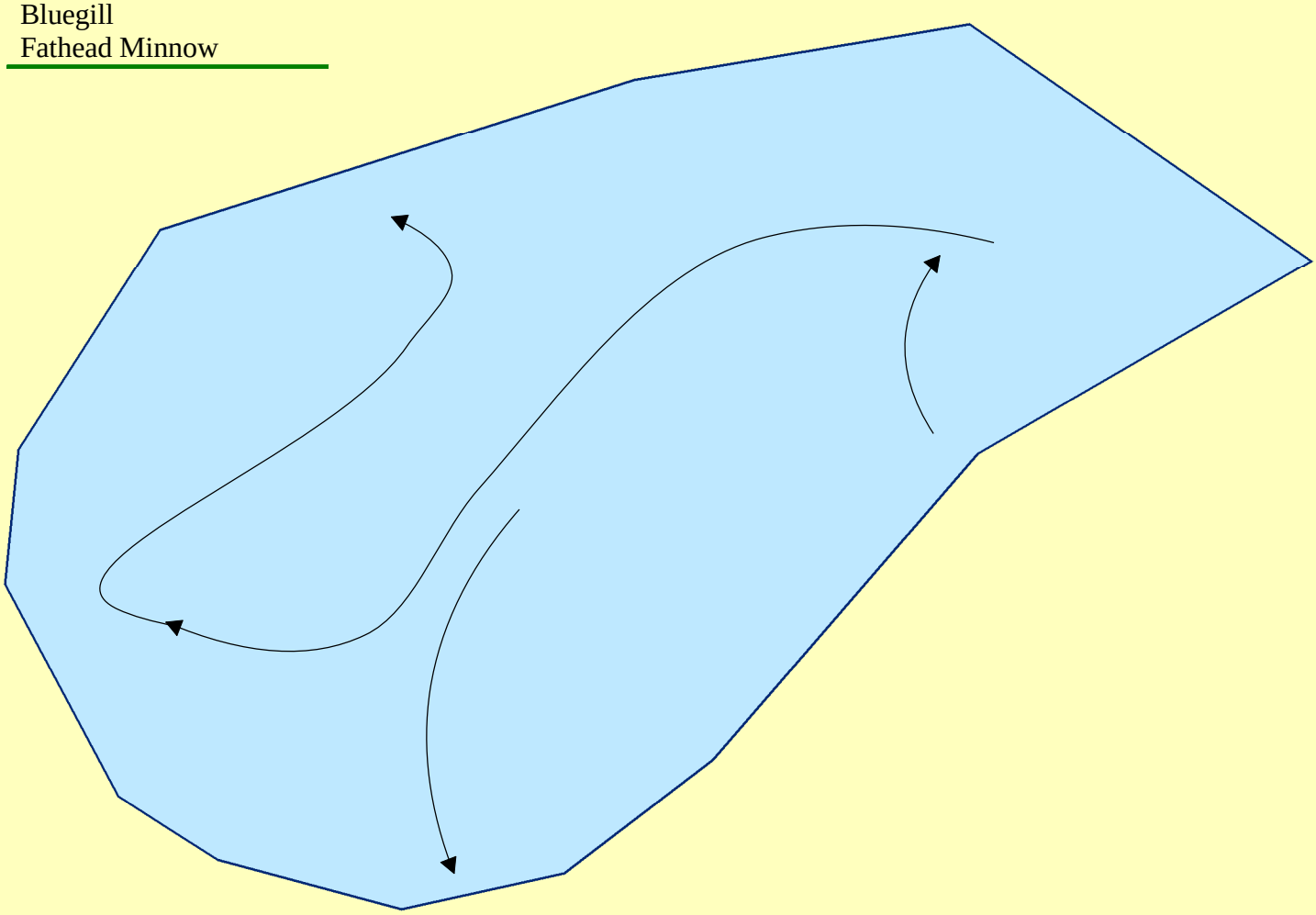
Streams
Roads
Beaver Pond
SLBE Lands

Figure 26. Good Harbor Creek Survey Summary.

Hidden Pond
Leelanau County

Species Caught
Northern Redbelly Dace
Pumpkinseed
Bluegill
Fathead Minnow

Surface Hectares = 0.6
Depth = 0.3 m



Date Surveyed: June 20, 2003
Electrofisher Settings: 90Hz 2ms @ 400volts
Shock Time: 5.8 minutes

0 12.5 25 50 75 100 Meters

Streams
Roads
SLBE Lands

Map Data Source: State of Michigan
Map Prepared By: Grand Traverse Band Ottawa/Chippewa
Map Projection: Michigan GeoReference
June, 2003

Figure 27. Hidden Pond Survey Summary.

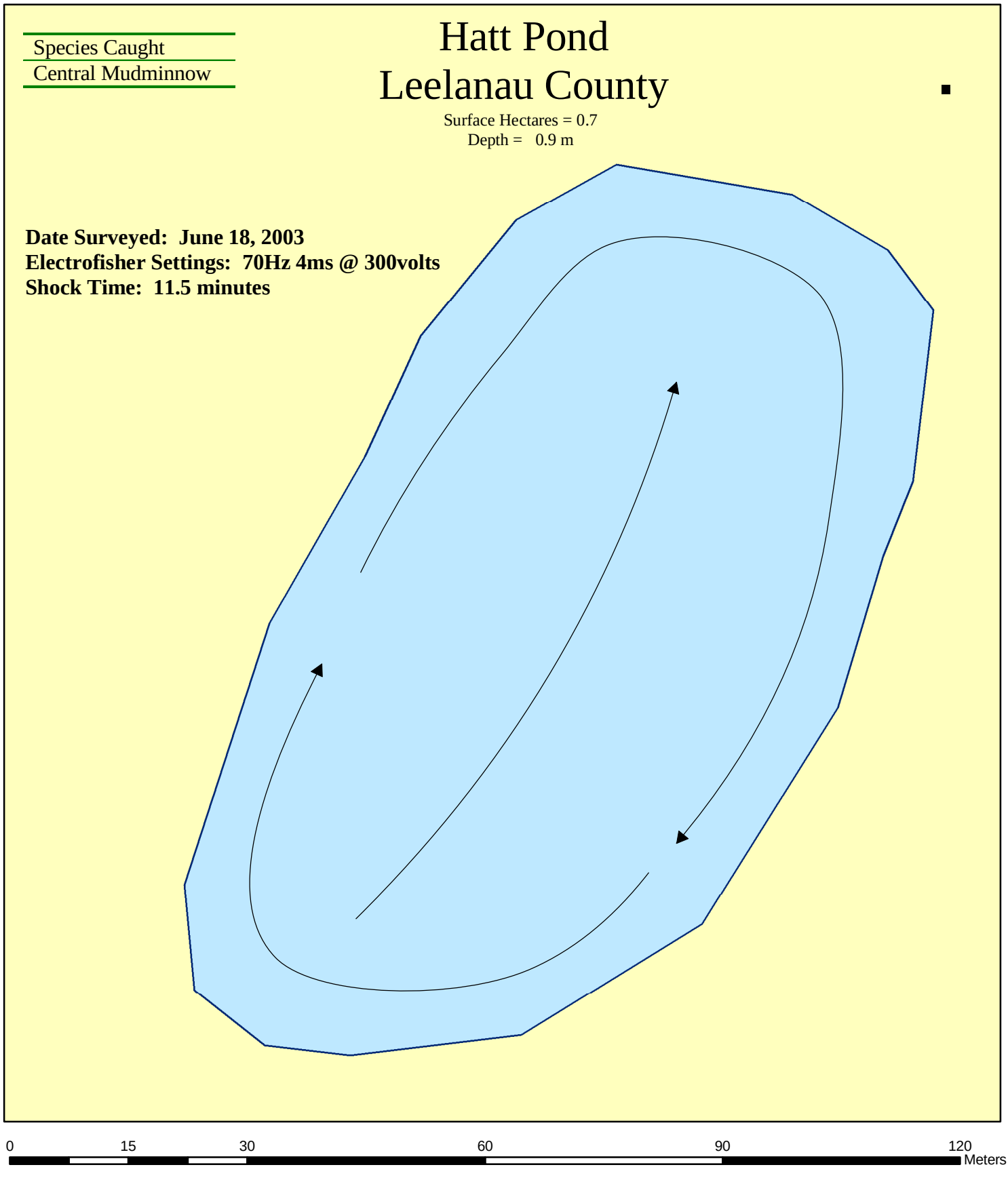


Figure 28. Hatt Pond Survey Summary.

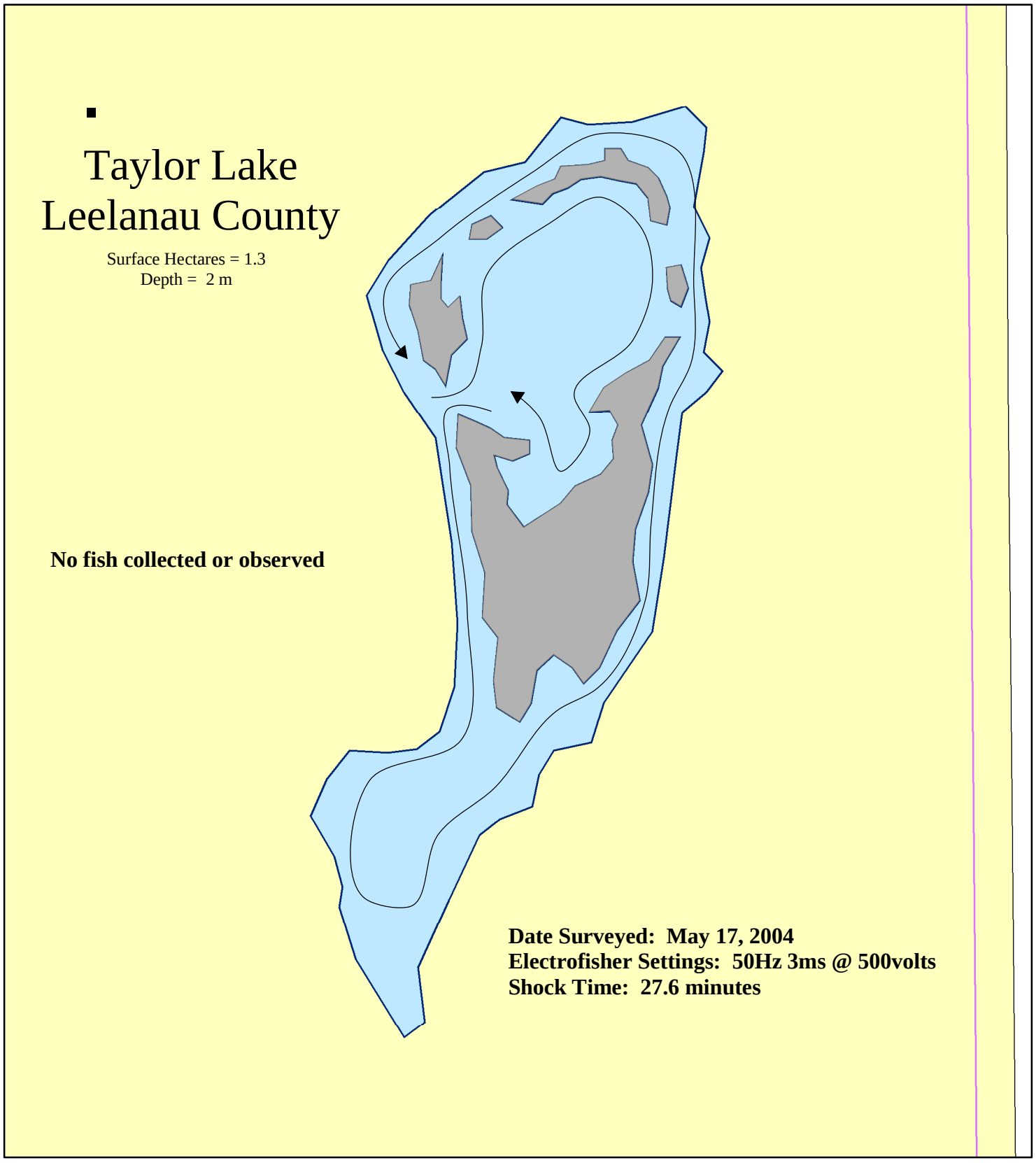
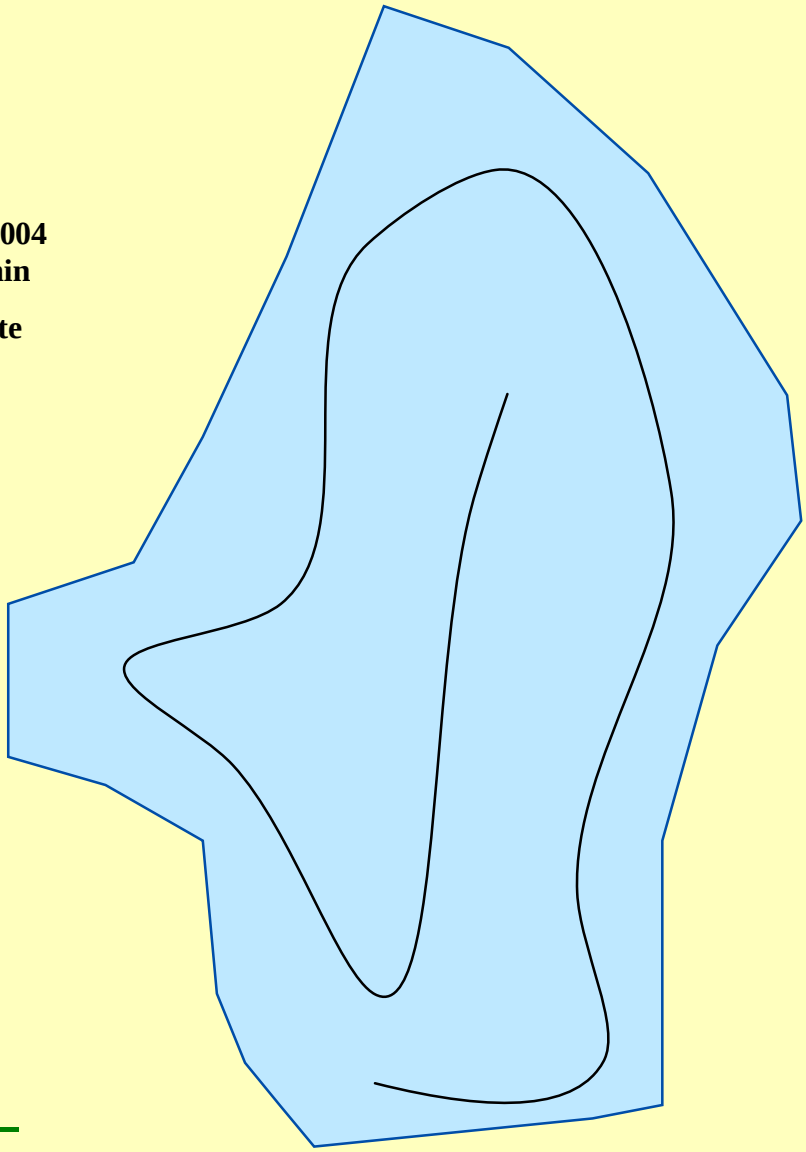


Figure 29. Taylor Lake Survey Summary.

Beck Pond
Leelanau County

Surface Hectares <1



Date Surveyed: June 9, 2004
Total Shock Time = 6.2 min

= Electrofishing Route

Species Caught
Green Sunfish
White Sucker

0 4 8 16 24 32 Meters

Streams
Roads
SLBE Lands

Map Data Source: State of Michigan
Map Prepared By: Grand Traverse Band Ottawa/Chippewa
Map Projection: Michigan GeoReference
May, 2004

Figure 30. Beck Pond Survey Summary.

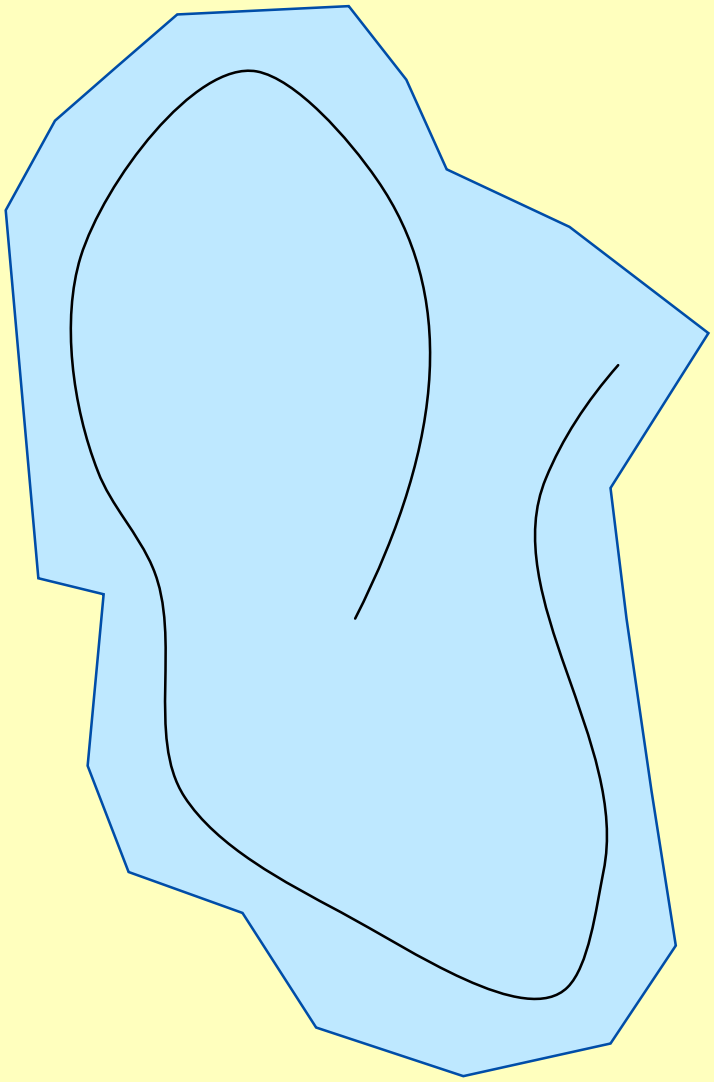
Esch Road Pond
Benzie County

Surface Hectares <1

Date Surveyed: June 9, 2004
Total Shock Time = 2.8 min

= Electrofishing Route

No fish species observed



0 5 10 20 30 40 Meters

Streams
Roads
SLBE Lands

Map Data Source: State of Michigan
Map Prepared By: Grand Traverse Band Ottawa/Chippewa
Map Projection: Michigan GeoReference
May, 2004

Figure 31. Esch Road Pond Survey Summary.

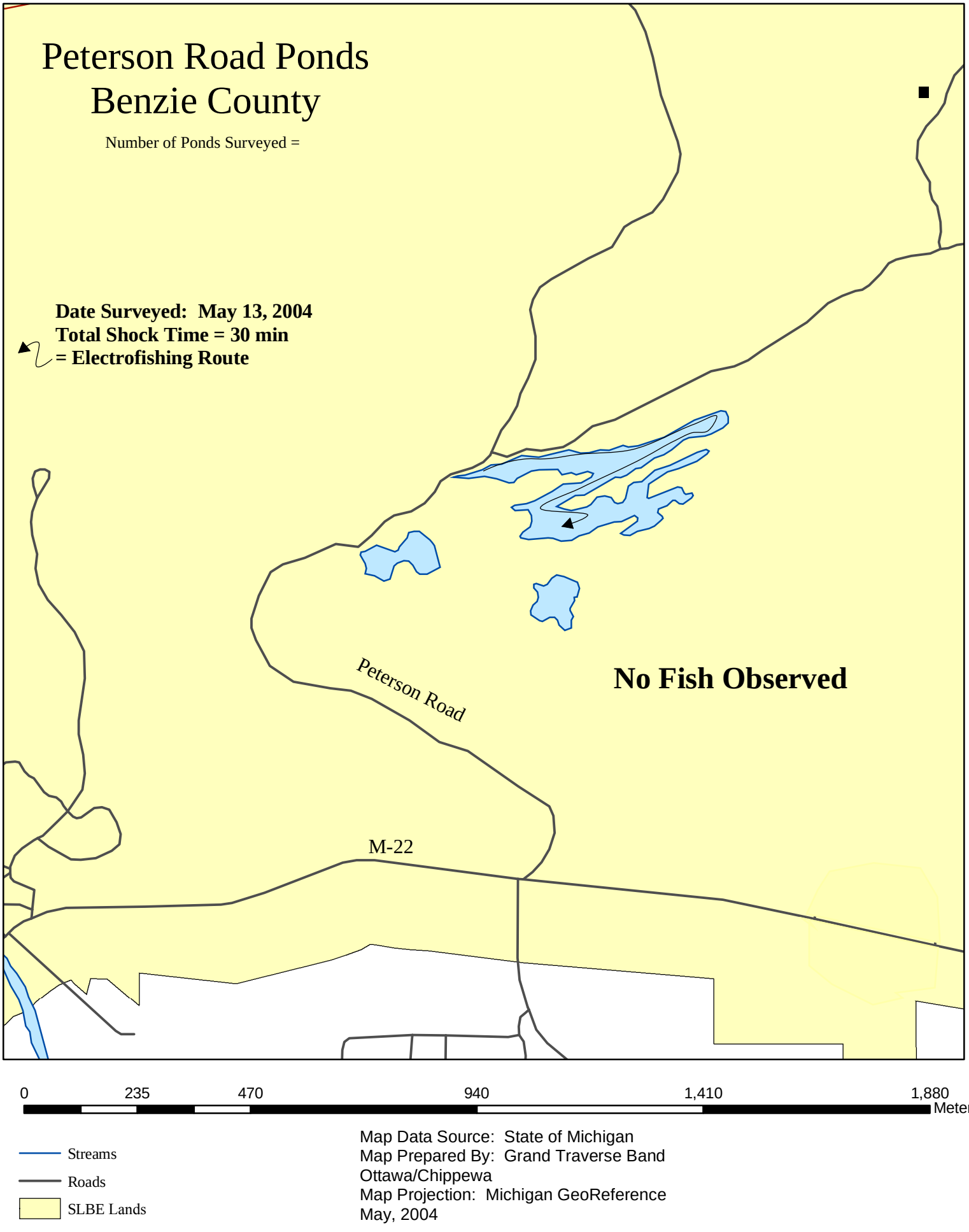


Figure 32. Peterson Road Ponds Survey Summary.

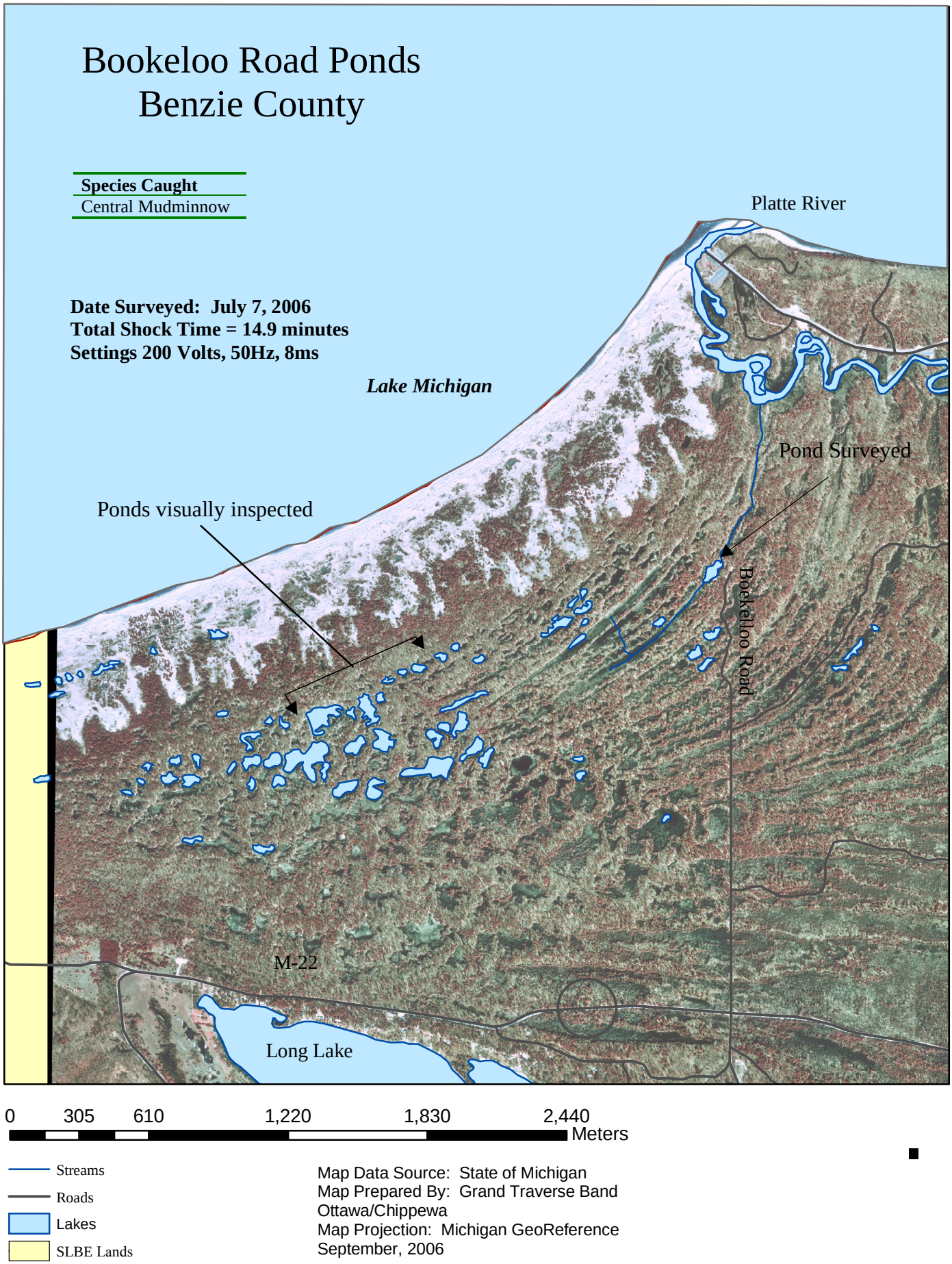


Figure 33. Boekeloo Road Ponds Survey Summary.



Figure 34. Bow Lakes Survey Summary.

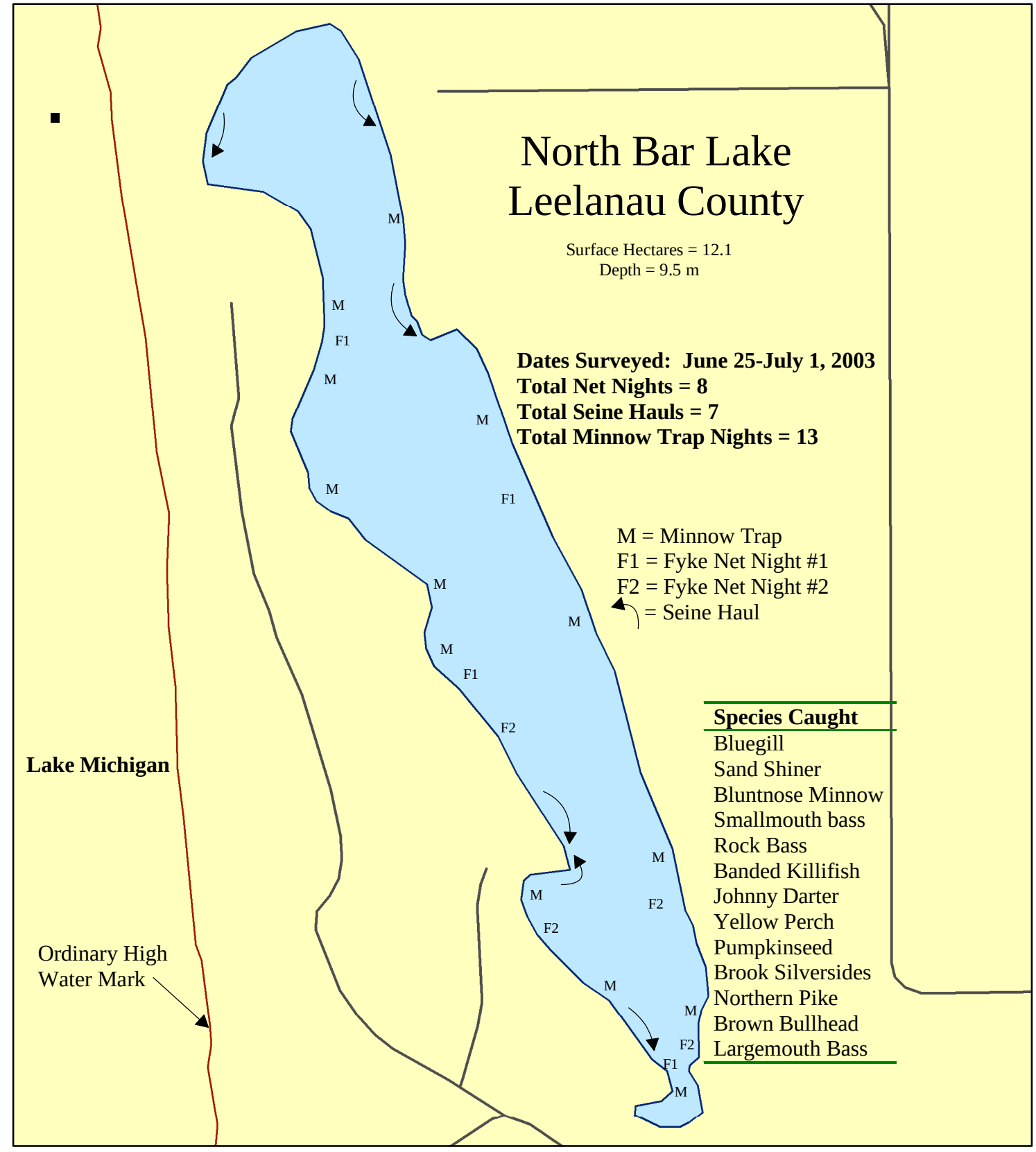


Figure 35. North Bar Lake Survey Summary.

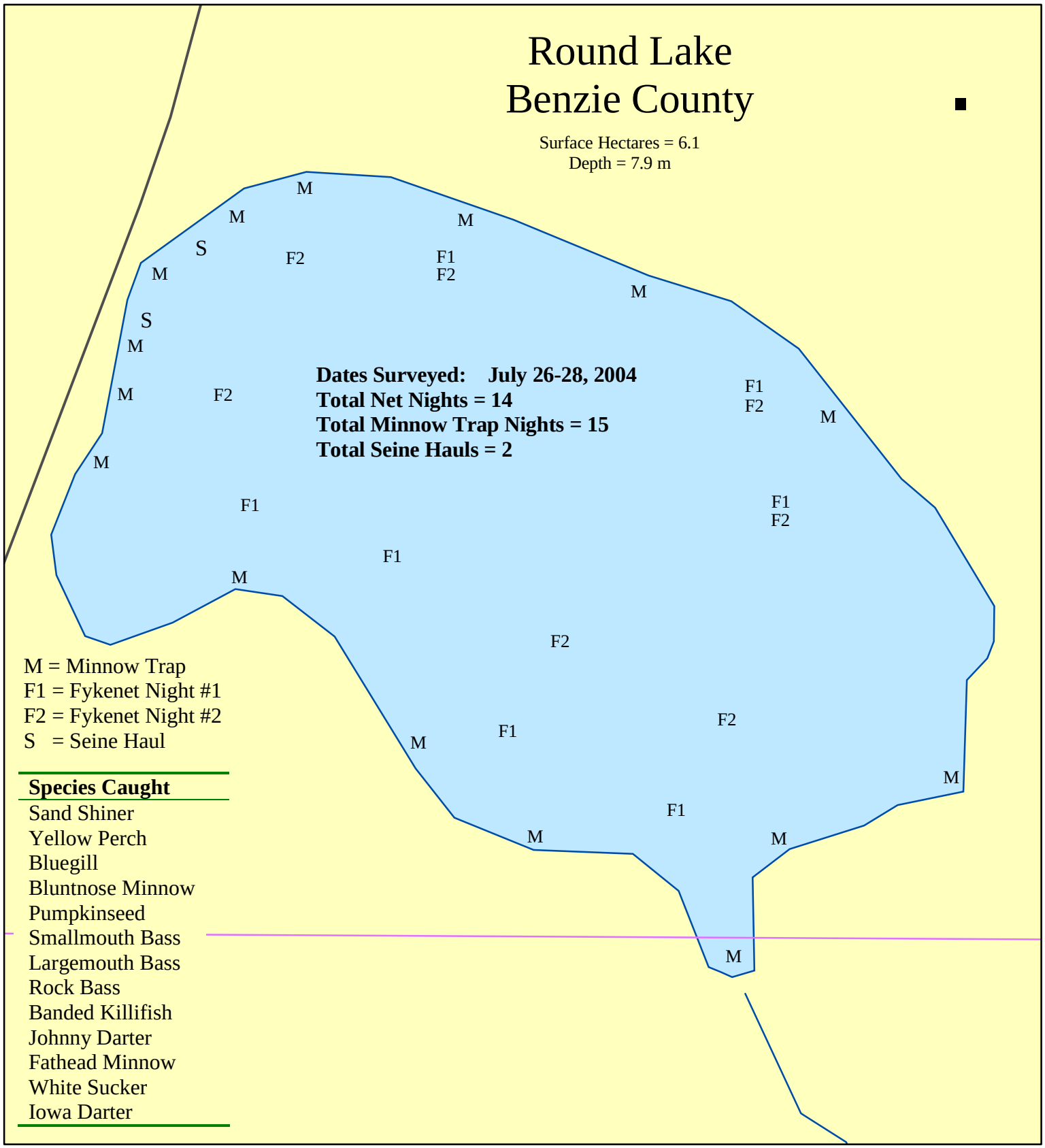


Figure 36. Round Lake Survey Summary.

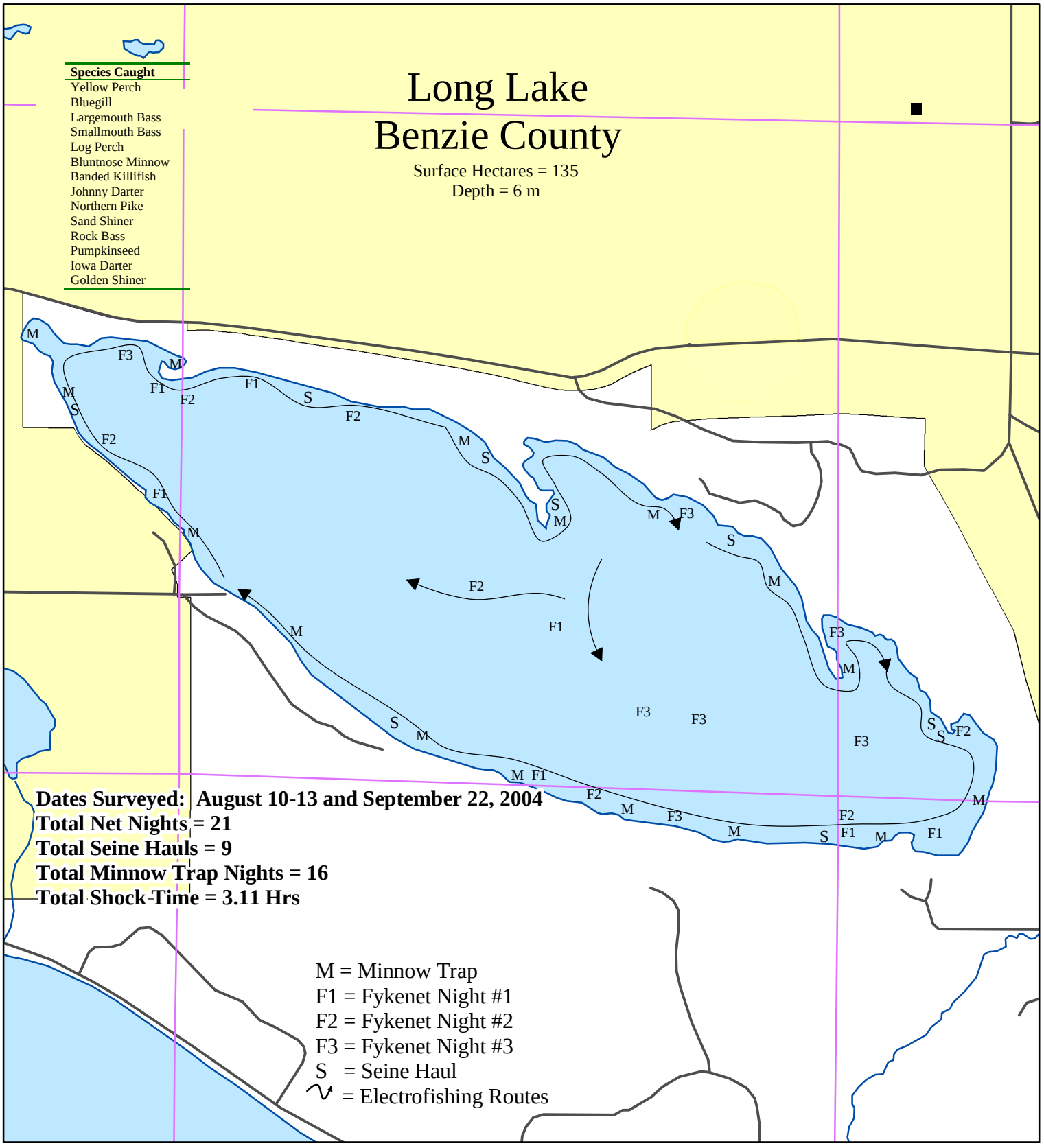


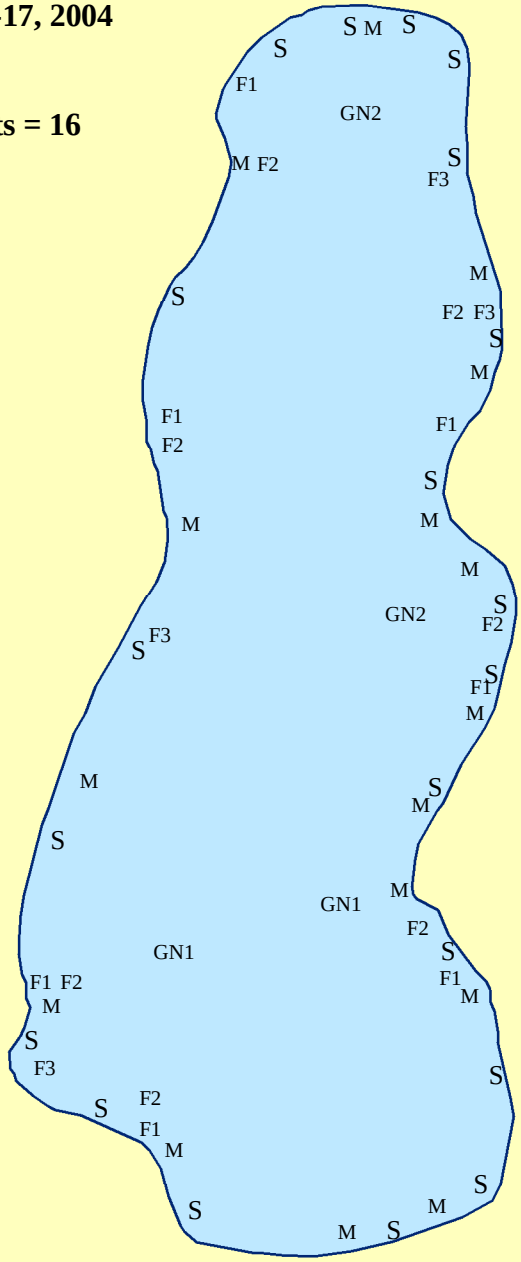
Figure 37. Long Lake Survey Summary.

Lake Manitou
North Manitou Island
Leelanau County

Surface Hectares = 104
Depth = 13.7 m

Dates Surveyed: June 14-17, 2004
Total Net Nights = 22
Total Seine Hauls = 20
Total Minnow Trap Nights = 16

Species Caught
Yellow Perch
Green Sunfish
White Sucker
Smallmouth Bass
Bluntnose Minnow
Iowa Darter



M = Minnow Trap
F1 = Fykenet Night #1
F2 = Fykenet Night #2
F3 = Fykenet Night #3
GN1 = Gill Net Night #1
GN2 = Gill Net Night #2
S = Seine Haul

0 280 560 1,120 1,680 2,240 Meters

Streams
Roads
SLBE Lands

Map Data Source: State of Michigan
Map Prepared By: Grand Traverse Band Ottawa/Chippewa
Map Projection: Michigan GeoReference
February, 2005

Figure 38. Lake Manitou Survey Summary.

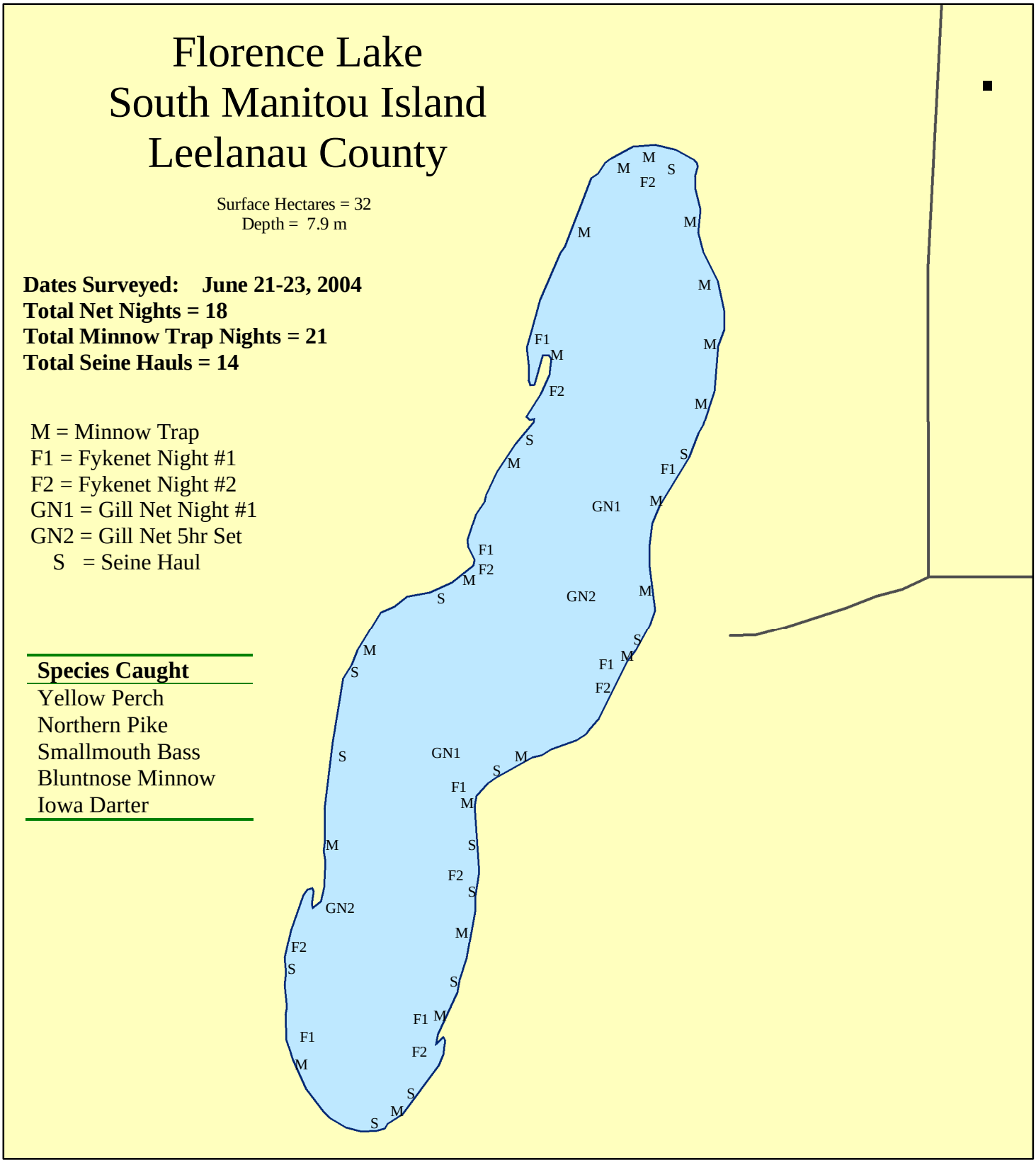


Figure 39. Florence Lake Survey Summary.



Figure 40. Good Harbor Bay Beach Seine Summary.

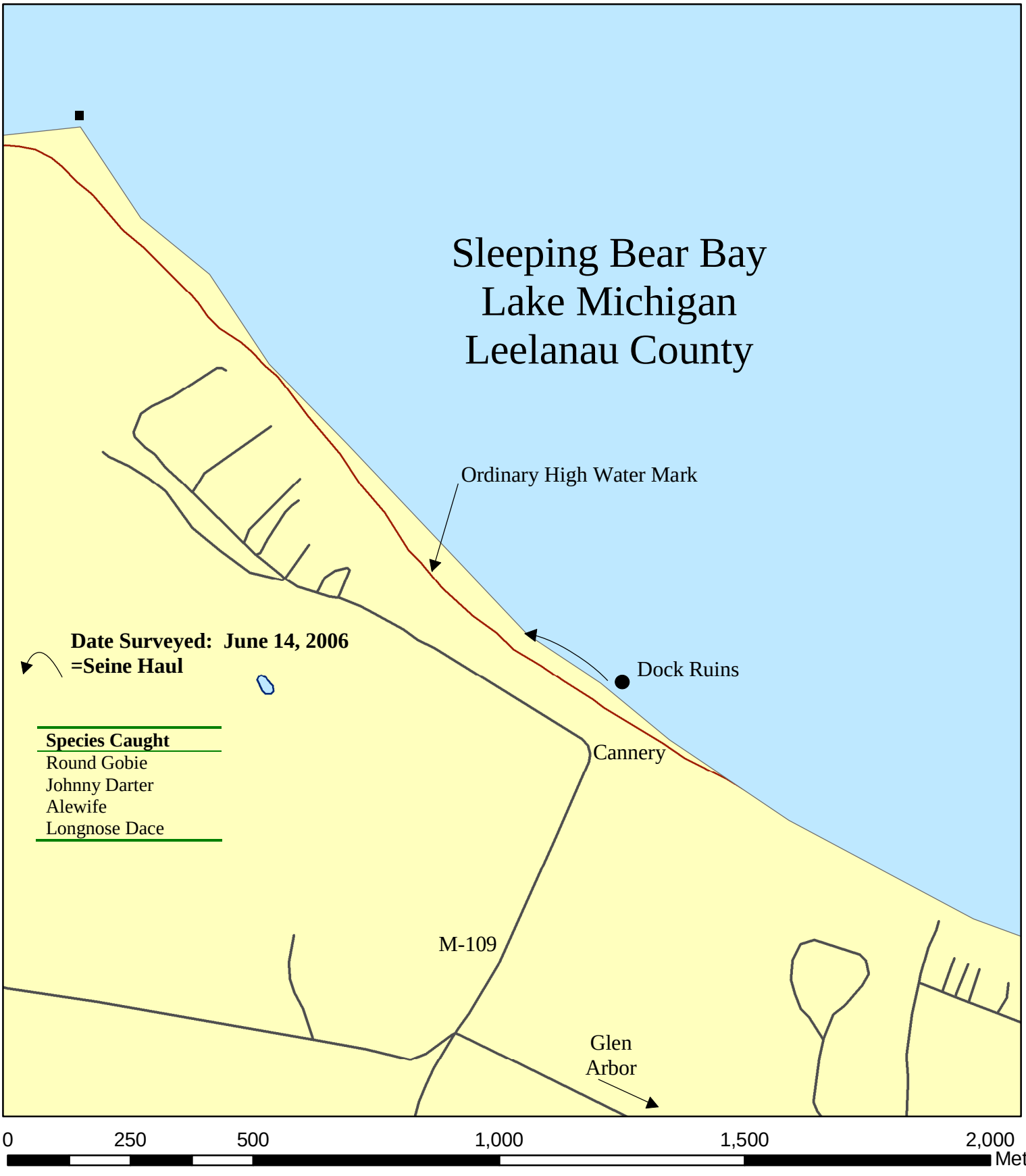


Figure 41. Sleeping Bear Bay Beach Seine Summary.



Figure 42. North Bar Beach Seine Summary.



Figure 43. Esch Road Beach Seine Summary.

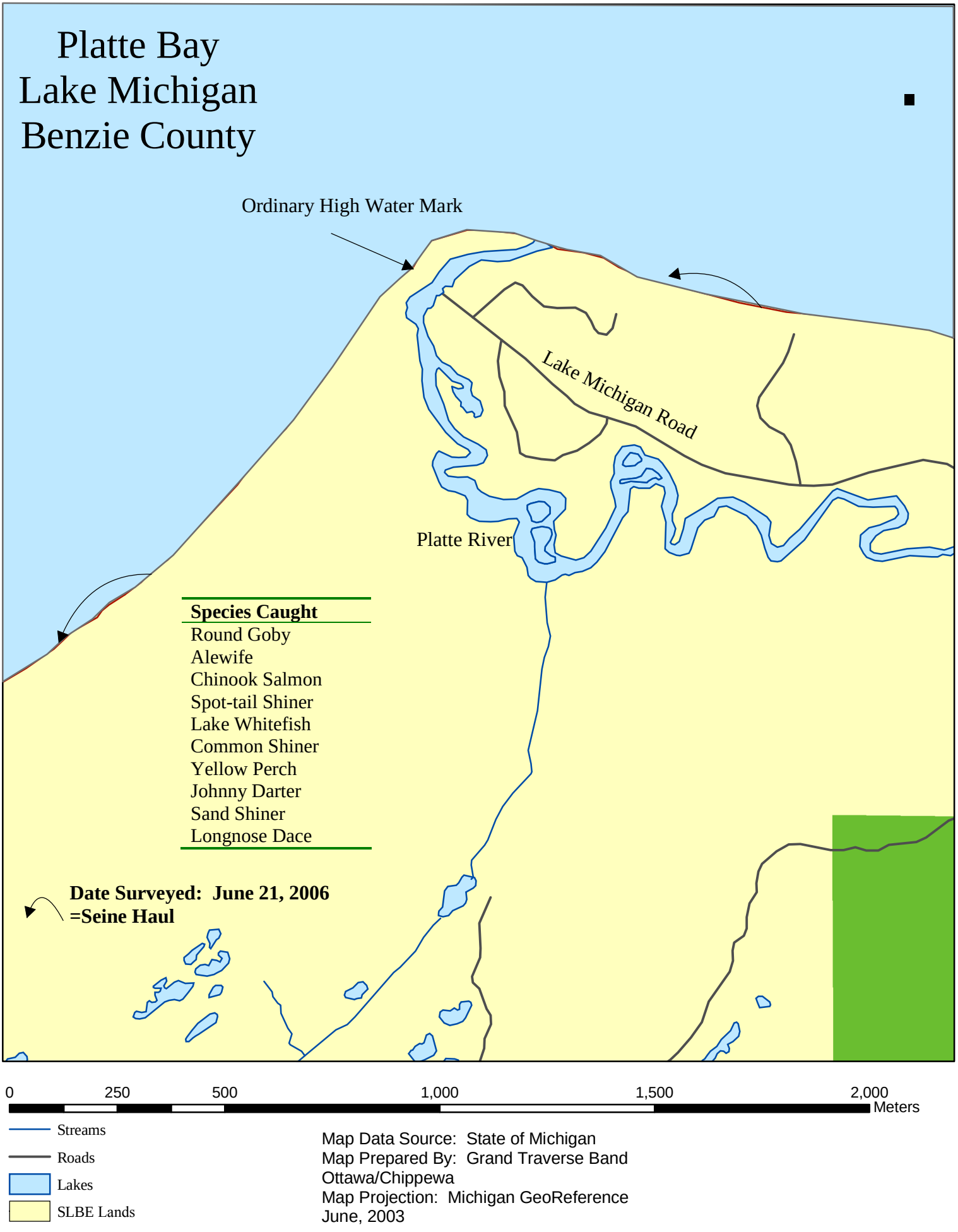


Figure 44. Platte Bay Beach Seine Summary.

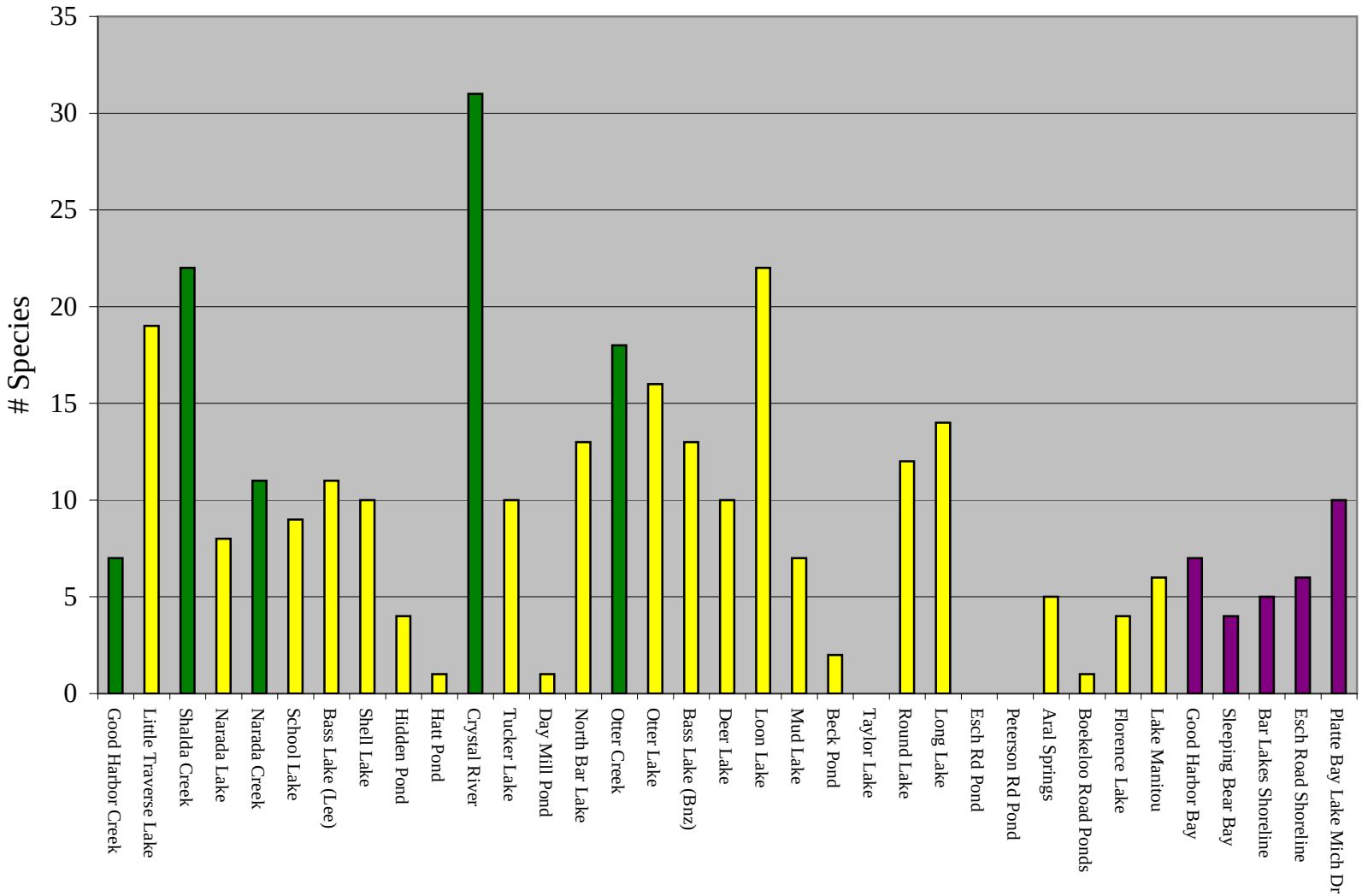


Figure 45. Number of species observed per waterbody, Sleeping Bear Dunes National Lakeshore, 2003-2006. Green = rivers/streams, yellow - lakes, purple = Lake Michigan sites.

Appendices

Appendix A. Summary of fishery surveys in the Shalda Creek Watershed, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control 1960s), M[1] = MDNR (1965), M[2] = MDNR (1974), M[3] = MDNR (1970).

Family	Species	Shalda Creek	Narada Lake	Narada Creek	School Lake	Bass Lake	Shell Lake	Traverse Lake
Petromyzontidae	American Brook Lamprey							
	Chestnut Lamprey	F						
	Lamprey, Ichthyomyzon	F						
	Sea Lamprey	F						
	Silver Lamprey							
Lepidostidae	Longnose Gar							
Amiidae	Bowfin	N						N
Clupeidae	Alewife	N,F	X					M[3]
Salmonidae	Brook Trout	M[1]						
	Brown Trout	N, M[1]						
	Lake Trout							
	Rainbow Trout	N, F						
	Chinook Salmon	X						
	Coho Salmon	F						
	Lake Herring							M[3]
Osmeridae	Rainbow Smelt	F						
Umbridae	Central Mudminnow	N, X, F, M[1]	N	N				
Esocidae	Muskellunge							
	Northern Pike	N, F	N		N, X, M[2]	N, X		M[3,] N
Cyprinidae	Blacknose Dace	F						
	Blacknose Shiner	M[1]		N				
	Bluntnose Minnow	N, X, F	N		X	N, X	N, X	N

Appendix A continued. Summary of fishery surveys in the Shalda Creek Watershed, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control 1960s), M^1 = MDNR (1965), M^2 = MDNR (1974), M^3 = MDNR (1970).

Family	Species	Shalda Creek	Narada Lake	Narada Creek	School Lake	Bass Lake	Shell Lake	Traverse Lake
Cyprinidae	Common Carp							
(continued)	Common Shiner	N, X, F		N				N
	Creek Chub	N, X, F		N, X				
	Emerald Shiner	N, M^1						
	Fathead Minnow							
	Golden Shiner		X					
	Hornyhead Chub	N						N
	Lake Chub							
	Longnose Dace	N, F						
	Mimic Shiner	N, F			N	N	N	
	Northern Redbelly Dace	F		N				
	Rosyface Shiner							
	Sand Shiner	X					N	N
	Spottail Shiner	N, F						
Catostomidae	Shorthead Redhorse							
	Silver Redhorse							
	White Sucker	N, X, F, M^1	X	N		N, X	X	M^3, N
Ictaluridae	Black Bullhead							
	Brown Bullhead		N		N, M^2	N, X		M^3, N
	Yellow Bullhead				X, M^2	X		
Fundulidae	Banded Killifish	N, X, F			N	N, X	N, X	N
Atherinidae	Brook Silversides							

Appendix A continued. Summary of fishery surveys in the Shalda Creek Watershed, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control 1960s), M^1 = MDNR (1965), M^2 = MDNR (1974), M^3 = MDNR (1970).

Family	Species	Shalda Creek	Narada Lake	Narada Creek	School Lake	Bass Lake	Shell Lake	Traverse Lake
Gasterosteidae	Brook Stickleback		X	N				
	Ninespine Stickleback	F						
Cottidae	Slimy Sculpin	X						
	Mottled Sculpin	N, F						N
Centrarchidae	Black Crappie							M^3
	Bluegill	N, X	N, X	N	N, X, M^2	N, X	N, X	M^3, N
	Green Sunfish							
	Largemouth Bass	X	N, X		N, X, M^2	N	N, X	M^3, N
	Longear Sunfish							
	Pumpkinseed	N	N, X	N	N, X, M^2	N	N, X	M^3, N
	Rock Bass	N, M^1	N		N, M^2	N, X		M^3, N
	Smallmouth Bass	N, F					X	M^3, N
Percidae	Blackside Darter							
	Fantailed Darter	M^1						
	Iowa Darter						N, X	
	Johnny Darter	N, X, F		N			N	N
	Log Perch	F						N
	Walleye							
	Yellow Perch	X	N, X	N	N	N	N, X	M^3, N

Appendix B. Summary of fishery surveys in the Crystal River Watershed, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04), X = Sea Grant Survey (1979), F-USFWS (Sea Lamprey Control 1960s), M = MDNR (1965), O = Other Reports.

Family	Species	Crystal River	Tucker Lake	Tucker Creek	Fisher Lake	Day Mill Pond
Petromyzontidae	American Brook Lamprey	F			Not Sampled in 2003-06	
	Chestnut Lamprey					
	Lamprey, Ichthyomyzon sp					
	Sea Lamprey	F				
	Silver Lamprey					
Lepidostidae	Longnose Gar					
Amiidae	Bowfin					
Clupeidae	Alewife	M				
Salmonidae	Brook Trout	F, M				
	Brown Trout	F				
	Lake Trout					
	Rainbow Trout	F				
	Chinook Salmon	F				
	Coho Salmon	F				
	Lake Herring					
Osmeridae	Rainbow Smelt					
Umbridae	Central Mudminnow	X, O	N	X		N
Esocidae	Muskellunge					
	Northern Pike	F, X, O	N, X		X	X
Cyprinidae	Blacknose Dace	F, O				
	Blacknose Shiner					
	Bluntnose Minnow	X			X	
	Common Carp					

Appendix B continued. Summary of fishery surveys in the Crystal River Watershed, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04), X = Sea Grant Survey (1979), F-USFWS (Sea Lamprey Control 1960s), M = MDNR (1965), O = Other Reports.

Family	Species	Crystal River	Tucker Lake	Tucker Creek	Fisher Lake	Day Mill Pond
Cyprinidae	Common Shiner	F, X, O			Not Sampled in 2003-06	
(continued)	Creek Chub	O				
	Emerald Shiner			O		
	Fathead Minnow					
	Golden Shiner					
	Hornyhead Chub	F, X, O			X	
	Lake Chub					
	Longnose Dace					
	Mimic Shiner					
	Northern Redbelly Dace					
	Rosyface Shiner					
	Sand Shiner	O				
	Spottail Shiner				X	
Catostomidae	Shorthead Redhorse					
	Silver Redhorse					
	White Sucker	F, M				
Ictaluridae	Black Bullhead	O				
	Brown Bullhead		N			
	Yellow Bullhead	X	N			
Fundulidae	Banded Killifish					
Atherinidae	Brook Silversides					
Gasterosteidae	Brook Stickleback	F, X				
	Ninespine Stickleback					

Appendix B continued. Summary of fishery surveys in the Crystal River Watershed, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04), X = Sea Grant Survey (1979), F-USFWS (Sea Lamprey Control 1960s), M = MDNR (1965), O = Other Reports.

Family	Species	Crystal River	Tucker Lake	Tucker Creek	Fisher Lake	Day Mill Pond
Cottidae	Slimy Sculpin				Not Sampled in 2003-06	
	Mottled Sculpin					
Centrarchidae	Black Crappie	F				
	Bluegill	F, X, M, O	N, X			
	Green Sunfish					
	Largemouth Bass	F, M, O	N, X		X	
	Longear Sunfish					
	Pumpkinseed	O	N, X	X		
	Rock Bass	F, X, M, O	N, X		X	
	Smallmouth Bass	F, M, O			X	
Percidae	Blackside Darter	F				
	Fantailed Darter					
	Iowa Darter	F	N		X	
	Johnny Darter	F, X, O			X	
	Log Perch	O				
	Walleye					
	Yellow Perch	X, M, O	N, X		X	

Appendix C. Summary of fishery surveys in the Otter Creek Watershed, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control 1960s), O = Other Reports.

Family	Species	Otter Creek	Otter Lake	Upper Otter Creek	Bass Lake	Deer Lake
Petromyzontidae	American Brook Lamprey					
	Chestnut Lamprey					
	Lamprey, Ichthyomyzon sp					
	Sea Lamprey					
	Silver Lamprey					
Lepidostidae	Longnose Gar					
Amiidae	Bowfin					
Clupeidae	Alewife					
Salmonidae	Brook Trout	N, X, F		F		
	Brown Trout	O				
	Lake Trout					
	Rainbow Trout					
	Chinook Salmon	O			N	
	Coho Salmon	O, F	N	F	N	
	Lake Herring					
Osmeridae	Rainbow Smelt					
Umbridae	Central Mudminnow	N, X, F		N, F	N	
Esocidae	Muskellunge					
	Northern Pike		N		N	N, X
Cyprinidae	Blacknose Dace	N, X				
	Blacknose Shiner	X	N	N		N
	Bluntnose Minnow	N, X, F	N, X	N	N, X	N
	Common Carp					

Appendix C continued. Summary of fishery surveys in the Otter Creek Watershed, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control 1960s), O = Other Reports.

Family	Species	Otter Creek	Otter Lake	Upper Otter Creek	Bass Lake	Deer Lake
Cyprinidae	Common Shiner	N, X, F	N, X	N, F		
(continued)	Creek Chub	N, X, F	X	N, F, X		
	Emerald Shiner					
	Fathead Minnow					
	Golden Shiner					
	Hornyhead Chub	N, X				
	Lake Chub					
	Longnose Dace	N				
	Mimic Shiner					
	Northern Redbelly Dace					
	Rosyface Shiner					
	Sand Shiner	N, X	X			
	Spottail Shiner	X				
Catostomidae	Shorthead Redhorse					
	Silver Redhorse					
	White Sucker	N, X, F	N, X	N	N	
Ictaluridae	Black Bullhead				X	
	Brown Bullhead		N			N
	Yellow Bullhead					
Fundulidae	Banded Killifish	N, X	N			
Atherinidae	Brook Silversides					
Gasterosteidae	Brook Stickleback	N, X, F		N		
	Ninespine Stickleback					

Appendix C continued. Summary of fishery surveys in the Otter Creek Watershed, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control 1960s), O = Other Reports.

Family	Species	Otter Creek	Otter Lake	Upper Otter Creek	Bass Lake	Deer Lake
Cottidae	Slimy Sculpin					
	Mottled Sculpin	N, F				
Centrarchidae	Black Crappie		N, X		N	N
	Bluegill	N	N	N	N, X	N
	Green Sunfish					
	Largemouth Bass	N, F	N, X	N, F	N, X	N, X
	Longear Sunfish				X	
	Pumpkinseed	N, F	N	N, F	N, X	N
	Rock Bass	N, F		N, F	N, X	N
	Smallmouth Bass	N, X	N			
Percidae	Blackside Darter					
	Fantailed Darter					
	Iowa Darter		N	N	X	X
	Johnny Darter	F	N, X	F	N, X	
	Log Perch					
	Walleye					
	Yellow Perch	N, X	N, X	N	N, X	N

Appendix D. Summary of fishery surveys in the Platte River Watershed, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04), X = Sea Grant Survey (1979), F = USFWS, M = MDNR, U = University of Michigan.

Family	Species	Lower Platte	Loon Lake	Mud Lake	Platte Lakes
Petromyzontidae	American Brook Lamprey				M, F
	Chestnut Lamprey	F, U			M
	Lamprey, Ichthyomyzon sp				
	Sea Lamprey		N		M, F
	Silver Lamprey				M, U
Lepidostidae	Longnose Gar		N		M, F, U
Amiidae	Bowfin		N		M
Clupeidae	Alewife		N		M, F
Salmonidae	Brook Trout				M
	Brown Trout				M, F
	Lake Trout				M
	Rainbow Trout				M, F
	Chinook Salmon				M, F
	Coho Salmon				M, F
	Lake Herring				M, U
Osmeridae	Rainbow Smelt				M
Umbridae	Central Mudminnow		N	N	M, F
Esocidae	Muskellunge				M, F, U
	Northern Pike		N	X	M, F
Cyprinidae	Blacknose Dace				M, F, U
	Blacknose Shiner				M
	Bluntnose Minnow	X	N	X	M, F
	Common Carp		N		M, F

Appendix D continued. Summary of fishery surveys in the Platte River Watershed, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04), X = Sea Grant Survey (1979), F = USFWS, M = MDNR, U = University of Michigan.

Family	Species	Lower Platte	Loon Lake	Mud Lake	Platte Lakes
Cyprinidae	Common Shiner		N		M, F
(continued)	Creek Chub				M, F
	Emerald Shiner				
	Fathead Minnow				
	Golden Shiner				
	Hornyhead Chub	X	N		M, F
	Lake Chub				U
	Longnose Dace				
	Mimic Shiner				F
	Northern Redbelly Dace				
	Rosyface Shiner				M, F
	Sand Shiner	X	N	N, X	F
	Spottail Shiner	X	N		F
Catostomidae	Shorthead Redhorse		X		M
	Silver Redhorse	U			M
	White Sucker		N		M, F
	Longnose sucker				M, F
Ictaluridae	Black Bullhead				
	Brown Bullhead		N		M, U
	Yellow Bullhead				M
Fundulidae	Banded Killifish			X	
Atherinidae	Brook Silversides				

Appendix D continued. Summary of fishery surveys in the Platte River Watershed, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04), X = Sea Grant Survey (1979), F = USFWS, M = MDNR, U = University of Michigan.

Family	Species	Lower Platte	Loon Lake	Mud Lake	Platte Lakes
Gasterosteidae	Brook Stickleback				M, F
	Ninespine Stickleback				
Cottidae	Slimy Sculpin				M, U
	Mottled Sculpin				M, F
Centrarchidae	Black Crappie				
	Bluegill		N	N, X	M, F
	Green Sunfish				
	Largemouth Bass		N	N, X	M, F
	Longear Sunfish				M, U
	Pumpkinseed		N, X	N	M, F
	Rock Bass		N, X	X	M, F
	Smallmouth Bass		N	X	M, F
Percidae	Blackside Darter				
	Fantailed Darter				
	Iowa Darter			N	F
	Johnny Darter		N	X	F
	Log Perch				M, F, U
	Walleye		N		M
	Yellow Perch		N	N	M, F

Appendix E. Summary of fishery surveys in various small watersheds, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04), X = Sea Grant Survey (1979) .

Family	Species	Hidden Pond	Hatt Pond	North Bar Lake	Round Lake
Petromyzontidae	American Brook Lamprey				
	Chestnut Lamprey				
	Lamprey, Ichthyomyzon sp				
	Sea Lamprey				
	Silver Lamprey				
Lepidostidae	Longnose Gar				
Amiidae	Bowfin				
Clupeidae	Alewife			X	
Salmonidae	Brook Trout				
	Brown Trout				
	Lake Trout				
	Rainbow Trout				
	Chinook Salmon				
	Coho Salmon				
	Lake Herring				
Osmeridae	Rainbow Smelt				
Umbridae	Central Mudminnow		N		
Esocidae	Muskellunge				
	Northern Pike			N, X	
Cyprinidae	Blacknose Dace				
	Blacknose Shiner				X
	Bluntnose Minnow			N	N, X
	Common Carp			N	

Appendix E continued. Summary of fishery surveys in various small watersheds, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04), X = Sea Grant Survey (1979) .

Family	Species	Hidden Pond	Hatt Pond	North Bar Lake	Round Lake
Cyprinidae	Common Shiner				
(continued)	Creek Chub				
	Emerald Shiner				
	Fathead Minnow	N, X			N
	Golden Shiner				X
	Hornyhead Chub				
	Lake Chub				
	Longnose Dace				
	Mimic Shiner				
	Northern Redbelly Dace	N, X			
	Rosyface Shiner				
	Sand Shiner			N, X	N, X
	Spottail Shiner			X	
Catostomidae	Shorthead Redhorse				
	Silver Redhorse				
	White Sucker				N, X
Ictaluridae	Black Bullhead				
	Brown Bullhead				
	Yellow Bullhead				
Fundulidae	Banded Killifish			N	N, X
Atherinidae	Brook Silversides			N	
Gasterosteidae	Brook Stickleback	X			
	Ninespine Stickleback				

Appendix E continued. Summary of fishery surveys in various small watersheds, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04), X = Sea Grant Survey (1979) .

Family	Species	Hidden Pond	Hatt Pond	North Bar Lake	Round Lake
Cottidae	Slimy Sculpin				
	Mottled Sculpin				
Centrarchidae	Black Crappie				
	Bluegill	N		N	N
	Green Sunfish				
	Largemouth Bass			N	N, X
	Longear Sunfish			N, X	
	Pumpkinseed	N		N	N
	Rock Bass			N	N
	Smallmouth Bass			N, X	N
Percidae	Blackside Darter				
	Fantailed Darter				
	Iowa Darter				
	Johnny Darter			N, X	N, X
	Log Perch				
	Walleye				
	Yellow Perch			N, X	N, X

Appendix F. Summary of fishery surveys on the Manitou Islands, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2004), X = Sea Grant Survey (1979), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975).

Family	Species	Rush Lake	Florence Lake	Lake Manitou
Petromyzontidae	American Brook Lamprey	Not Sampled in 2003-06		
	Chestnut Lamprey			
	Lamprey, Ichthyomyzon sp			
	Sea Lamprey			
	Silver Lamprey			
Lepidostidae	Longnose Gar			
Amiidae	Bowfin			
Clupeidae	Alewife			
Salmonidae	Brook Trout			
	Brown Trout			C
	Lake Trout			
	Rainbow Trout			
	Chinook Salmon			
	Coho Salmon			
	Lake Herring			
Osmeridae	Rainbow Smelt			
Umbridae	Central Mudminnow			
Esocidae	Muskellunge			
	Northern Pike	X	N, L, G	
Cyprinidae	Blacknose Dace			
	Blacknose Shiner			
	Bluntnose Minnow			N
	Common Carp			

Appendix F continued. Summary of fishery surveys on the Manitou Islands, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2004), X = Sea Grant Survey (1979), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975).

Family	Species	Rush Lake	Florence Lake	Lake Manitou
	Common Shiner	Not Sampled in 2003-06		
	Creek Chub			
	Emerald Shiner			
	Fathead Minnow			
	Golden Shiner	X		
	Hornyhead Chub			
	Lake Chub			
	Longnose Dace			
Cyprinidae	Mimic Shiner			
(continued)	Northern Redbelly Dace			
	Rosyface Shiner			
	Sand Shiner			
	Spottail Shiner			
Catostomidae	Shorthead Redhorse			
	Silver Redhorse			
	White Sucker			N, L
Ictaluridae	Black Bullhead			
	Brown Bullhead			
	Yellow Bullhead			
Fundulidae	Banded Killifish			
Atherinidae	Brook Silversides			
Gasterosteidae	Brook Stickleback			
	Ninespine Stickleback			

Appendix F continued. Summary of fishery surveys on the Manitou Islands, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2004), X = Sea Grant Survey (1979), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975).

Family	Species	Rush Lake	Florence Lake	Lake Manitou
Cottidae	Slimy Sculpin	Not Sampled in 2003-06		
	Mottled Sculpin			L
Centrarchidae	Black Crappie			
	Bluegill	X		
	Green Sunfish			N, L
	Largemouth Bass			
	Longear Sunfish			
	Pumpkinseed	X		
	Rock Bass			
	Smallmouth Bass		N, L, G	N, L, C
Percidae	Blackside Darter			
	Fantailed Darter			
	Iowa Darter	X	N, L, G	N, L
	Johnny Darter			
	Log Perch			
	Walleye			
	Yellow Perch		N, L, G	N, L, C

Appendix G. Summary of fishery surveys conducted in 2003-2006 but not in 1979, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/06).

Family	Species	Beck Pond	Taylor Lake	Long Lake	Esch Rd Pond	Peterson Rd Pond	Good Harbor Creek	Aral Springs	Boekeloo Rd Ponds
Petromyzontidae	American Brook Lamprey		No Fish Observed		No Fish Observed	No Fish Observed			
	Chestnut Lamprey								
	Lamprey, Ichthyomyzon sp								
	Sea Lamprey								
	Silver Lamprey								
Lepidostidae	Longnose Gar								
Amiidae	Bowfin								
Clupeidae	Alewife								
Salmonidae	Brook Trout							N	
	Brown Trout								
	Lake Trout								
	Rainbow Trout								
	Chinook Salmon								
	Coho Salmon								
	Lake Herring								
Osmeridae	Rainbow Smelt								
Umbridae	Central Mudminnow						N	N	N
Esocidae	Muskellunge								
	Northern Pike			N					
Cyprinidae	Blacknose Dace								
	Blacknose Shiner								
	Bluntnose Minnow			N			N		

Appendix G continued. Summary of fishery surveys conducted in 2003-2006 but not in 1979, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/06).

Family	Species	Beck Pond	Taylor Lake	Long Lake	Esch Rd Pond	Peterson Rd Pond	Good Harbor Creek	Aral Springs	Boekeloo Rd Ponds
Cyprinidae (continued)	Common Carp		No Fish Observed		No Fish Observed	No Fish Observed			
	Common Shiner								
	Creek Chub								
	Emerald Shiner								
	Fathead Minnow								
	Golden Shiner			N					
	Hornyhead Chub								
	Lake Chub								
	Longnose Dace								
	Mimic Shiner								
	Northern Redbelly Dace						N		
	Rosyface Shiner								
	Sand Shiner			N					
	Spottail Shiner								
Catostomidae	Shorthead Redhorse								
	Silver Redhorse								
	White Sucker	N							
Ictaluridae	Black Bullhead								
	Brown Bullhead						N		
	Yellow Bullhead								
Fundulidae	Banded Killifish			N			N		
Atherinidae	Brook Silversides								

Appendix G continued. Summary of fishery surveys conducted in 2003-2006 but not in 1979, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/06).

Family	Species	Beck Pond	Taylor Lake	Long Lake	Esch Rd Pond	Peterson Rd Pond	Good Harbor Creek	Aral Springs	Boekeloo Rd Ponds
Gasterosteidae	Brook Stickleback		No Fish Observed		No Fish Observed	No Fish Observed		N	
	Ninespine Stickleback								
Cottidae	Slimy Sculpin								
	Mottled Sculpin							N	
Centrarchidae	Black Crappie								
	Bluegill			N			N		
	Green Sunfish	N							
	Largemouth Bass			N					
	Longear Sunfish								
	Pumpkinseed			N			N		
	Rock Bass			N					
	Smallmouth Bass			N					
Percidae	Blackside Darter								
	Fantailed Darter								
	Iowa Darter			N					
	Johnny Darter			N					
	Log Perch			N					
	Walleye								
	Yellow Perch			N				N	

Appendix H. Summary of fishery surveys in the Lake Michigan, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2006) , X = Sea Grant Survey (1979).

Family	Species	Good Harbor Bay	Sleeping Bear Bay	Bar Lakes Shoreline	Esch Road Shoreline	Platte Bay
Petromyzontidae	American Brook Lamprey					
	Chestnut Lamprey					
	Lamprey, Ichthyomyzon sp					
	Sea Lamprey					
	Silver Lamprey					
Lepidostidae	Longnose Gar					
Amiidae	Bowfin					
Clupeidae	Alewife	N, X	N, X	N	N,X	N, X
Salmonidae	Brook Trout					
	Brown Trout					
	Lake Trout					
	Rainbow Trout					
	Chinook Salmon	N			N	N
	Coho Salmon					
	Lake Whitefish	N		N	N	N
	Lake Herring		X			
Osmeridae	Rainbow Smelt					
Umbridae	Central Mudminnow					
Esocidae	Muskellunge					
	Northern Pike					
Cyprinidae	Blacknose Dace					
	Blacknose Shiner					

Appendix H continued. Summary of fishery surveys in the Lake Michigan, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2006) , X = Sea Grant Survey (1979).

Family	Species	Good Harbor Bay	Sleeping Bear Bay	Bar Lakes Shoreline	Esch Road Shoreline	Platte Bay
Cyprinidae	Bluntnose Minnow				X	
(continued)	Common Carp					
	Common Shiner					N
	Creek Chub					
	Emerald Shiner	N		N		
	Fathead Minnow					
	Golden Shiner					
	Hornyhead Chub					
	Lake Chub					
	Longnose Dace	N, X	N, X			N
	Mimic Shiner					
	Northern Redbelly Dace					
	Rosyface Shiner					
	Sand Shiner	N		N	N	N
	Spottail Shiner	N, X	X	N	N	N, X
Catostomidae	Shorthead Redhorse					
	Silver Redhorse					
	White Sucker					
Ictaluridae	Black Bullhead					
	Brown Bullhead					
	Yellow Bullhead					
Fundulidae	Banded Killifish				N	

Appendix H continued. Summary of fishery surveys in the Lake Michigan, Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2006) , X = Sea Grant Survey (1979).

Family	Species	Good Harbor Bay	Sleeping Bear Bay	Bar Lakes Shoreline	Esch Road Shoreline	Platte Bay
Atherinidae	Brook Silversides					
Gasterosteidae	Brook Stickleback					
	Ninespine Stickleback					
Cottidae	Slimy Sculpin					
	Mottled Sculpin					
Centrarchidae	Black Crappie					
	Bluegill					
	Green Sunfish					
	Largemouth Bass					
	Longear Sunfish					
	Pumpkinseed					
	Rock Bass					
	Smallmouth Bass					
Percidae	Blackside Darter					
	Fantailed Darter					
	Iowa Darter					
	Johnny Darter		N			N
	Log Perch					
	Walleye					
	Yellow Perch					N
Gobiidae	Round Goby		N			N

Appendix I. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M[1] = MDNR (1965), M[2] = MDNR (1974), M[3] = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Shalda Creek	Narada Lake	Narada Creek	School Lake	Bass Lake	Shell Lake	Traverse Lake	Crystal River
Petromyzontidae	American Brook Lamprey								F
	Chestnut Lamprey	F							
	Lamprey, Ichthyomyzon sp	F							
	Sea Lamprey	F							F
	Silver Lamprey								
Lepidostidae	Longnose Gar								
Amiidae	Bowfin	N						N	
Clupeidae	Alewife	N,F	X					M[3]	M
Salmonidae	Brook Trout	M[1]							F, M
	Brown Trout	N, M[1]							F
	Lake Trout								
	Rainbow Trout	N, F							F
	Chinook Salmon	X							F
	Coho Salmon	F							F
	Lake Whitefish								
	Lake Herring							M[3]	
Osmeridae	Rainbow Smelt	F							
Umbridae	Central Mudminnow	N, X, F, M[1]	N	N					X, O
Esocidae	Muskellunge								

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M[1] = MDNR (1965), M[2] = MDNR (1974), M[3] = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Shalda Creek	Narada Lake	Narada Creek	School Lake	Bass Lake	Shell Lake	Traverse Lake	Crystal River
Esocidae (continued)	Northern Pike	N, F	N		N, X, M[2]	N, X		M[3], N	F, X, O
Cyprinidae	Blacknose Dace	F							F, O
	Blacknose Shiner	M[1]		N					
	Bluntnose Minnow	N, X, F	N		X	N, X	N, X	N	X
	Common Carp								
	Common Shiner	N, X, F		N				N	F, X, O
	Creek Chub	N, X, F		N, X					O
	Emerald Shiner	N, M[1]							
	Fathead Minnow								
	Golden Shiner		X						
	Hornyhead Chub	N						N	F, X, O
	Lake Chub								
	Longnose Dace	N, F							
	Mimic Shiner	N, F			N	N	N		
	Northern Redbelly Dace	F		N					
	Rosyface Shiner								
	Sand Shiner	X					N	N	O
	Spottail Shiner	N, F							

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M^1 = MDNR (1965), M^2 = MDNR (1974), M^3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Shalda Creek	Narada Lake	Narada Creek	School Lake	Bass Lake	Shell Lake	Traverse Lake	Crystal River
Catostomidae	Shorthead Redhorse								
	Silver Redhorse								
	White Sucker	N, X, F, M^1	X	N		N, X	X	M^3, N	F, M
	Longnose Sucker								
Ictaluridae	Black Bullhead								O
	Brown Bullhead		N		N, M^2	N, X		M^3, N	
	Yellow Bullhead				X, M^2	X			X
Fundulidae	Banded Killifish	N, X, F			N	N, X	N, X	N	
Atherinidae	Brook Silversides								
Gasterosteidae	Brook Stickleback		X	N					F, X
	Ninespine Stickleback	F							
Cottidae	Slimy Sculpin	X							
	Mottled Sculpin	N, F						N	
Centrarchidae	Black Crappie							M^3	F
	Bluegill	N, X	N, X	N	N, X, M^2	N, X	N, X	M^3, N	F, X, M, O
	Green Sunfish								
	Largemouth Bass	X	N, X		N, X, M^2	N	N, X	M^3, N	F, M, O
	Longear Sunfish								
	Pumpkinseed	N	N, X	N	N, X, M^2	N	N, X	M^3, N	O

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M[1] = MDNR (1965), M[2] = MDNR (1974), M[3] = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Shalda Creek	Narada Lake	Narada Creek	School Lake	Bass Lake	Shell Lake	Traverse Lake	Crystal River
Centrarchidae	Rock Bass	N, M[1]	N		N, M[2]	N, X		M[3], N	F, X, M, O
(continued)	Smallmouth Bass	N, F					X	M[3], N	F, M, O
Percidae	Blackside Darter								F
	Fantailed Darter	M[1]							
	Iowa Darter						N, X		F
	Johnny Darter	N, X, F		N			N	N	F, X, O
	Log Perch	F						N	O
	Walleye								
	Yellow Perch	X	N, X	N	N	N	N, X	M[3], N	N, X
Gobiidae	Round Goby								

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M^1 = MDNR (1965), M^2 = MDNR (1974), M^3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Tucker Lake	Tucker Creek	Fisher Lake	Day Mill Pond	Otter Creek	Otter Lake	Upper Otter Creek	Bass Lake
Petromyzontidae	American Brook Lamprey			Not Sampled in 2003-06					
	Chestnut Lamprey								
	Lamprey, Ichthyomyzon sp								
	Sea Lamprey								
	Silver Lamprey								
Lepidostidae	Longnose Gar								
Amiidae	Bowfin								
Clupeidae	Alewife								
Salmonidae	Brook Trout					N, X, F		F	
	Brown Trout					O			
	Lake Trout								
	Rainbow Trout								
	Chinook Salmon					O			N
	Coho Salmon					O, F	N	F	N
	Lake Whitefish								
	Lake Herring								
Osmeridae	Rainbow Smelt								
Umbridae	Central Mudminnow	N	X		N	N, X, F		N, F	N
Esocidae	Muskellunge								

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M^1 = MDNR (1965), M^2 = MDNR (1974), M^3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Tucker Lake	Tucker Creek	Fisher Lake	Day Mill Pond	Otter Creek	Otter Lake	Upper Otter Creek	Bass Lake
Esocidae (continued)	Northern Pike	N, X		X	X		N		N
Cyprinidae	Blacknose Dace					N, X			
	Blacknose Shiner					X	N	N	
	Bluntnose Minnow			X		N, X, F	N, X	N	N, X
	Common Carp			Not Sampled in 2003-06					
	Common Shiner					N, X, F	N, X	N, F	
	Creek Chub					N, X, F	X	N, F, X	
	Emerald Shiner		O						
	Fathead Minnow								
	Golden Shiner								
	Hornyhead Chub			X		N, X			
	Lake Chub								
	Longnose Dace					N			
	Mimic Shiner								
	Northern Redbelly Dace								
	Rosyface Shiner								
	Sand Shiner					N, X	X		
	Spottail Shiner			X		X			

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M^1 = MDNR (1965), M^2 = MDNR (1974), M^3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Tucker Lake	Tucker Creek	Fisher Lake	Day Mill Pond	Otter Creek	Otter Lake	Upper Otter Creek	Bass Lake
Catostomidae	Shorthead Redhorse			Not Sampled in 2003-06					
	Silver Redhorse								
	White Sucker					N, X, F	N, X	N	N
	Longnose Sucker								
Ictaluridae	Black Bullhead								X
	Brown Bullhead	N					N		
	Yellow Bullhead	N							
Fundulidae	Banded Killifish					N, X	N		
Atherinidae	Brook Silversides								
Gasterosteidae	Brook Stickleback					N, X, F		N	
	Ninespine Stickleback								
Cottidae	Slimy Sculpin								
	Mottled Sculpin					N, F			
Centrarchidae	Black Crappie						N, X		N
	Bluegill	N, X				N	N	N	N, X
	Green Sunfish								
	Largemouth Bass	N, X		X		N, F	N, X	N, F	N, X
	Longear Sunfish								X
	Pumpkinseed	N, X	X			N, F	N	N, F	N, X

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M^1 = MDNR (1965), M^2 = MDNR (1974), M^3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Tucker Lake	Tucker Creek	Fisher Lake	Day Mill Pond	Otter Creek	Otter Lake	Upper Otter Creek	Bass Lake
Centrarchidae	Rock Bass	N, X		X		N, F		N, F	N, X
(continued)	Smallmouth Bass			X		N, X	N		
Percidae	Blackside Darter								
	Fantailed Darter								
	Iowa Darter	N		X			N	N	X
	Johnny Darter			X		F	N, X	F	N, X
	Log Perch			Not Sampled					
	Walleye			in 2003-06					
	Yellow Perch	N, X		X		N, X	N, X	N	N, X
Gobiidae	Round Goby								

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M^1 = MDNR (1965), M^2 = MDNR (1974), M^3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Deer Lake	Lower Platte	Loon Lake	Mud Lake	Platte Lakes	Hidden Pond	Hatt Pond	North Bar Lake
Petromyzontidae	American Brook Lamprey					M, F			
	Chestnut Lamprey		F, U			M			
	Lamprey, Ichthyomyzon sp								
	Sea Lamprey			N		M, F			
	Silver Lamprey					M, U			
Lepidostidae	Longnose Gar			N		M, F, U			
Amiidae	Bowfin			N		M			
Clupeidae	Alewife			N		M, F			X
Salmonidae	Brook Trout					M			
	Brown Trout					M, F			
	Lake Trout					M			
	Rainbow Trout					M, F			
	Chinook Salmon					M, F			
	Coho Salmon					M, F			
	Lake Whitefish								
	Lake Herring					M, U			
Osmeridae	Rainbow Smelt					M			
Umbridae	Central Mudminnow			N	N	M, F		N	
Esocidae	Muskellunge					M, F, U			

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M^1 = MDNR (1965), M^2 = MDNR (1974), M^3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Deer Lake	Lower Platte	Loon Lake	Mud Lake	Platte Lakes	Hidden Pond	Hatt Pond	North Bar Lake
Esocidae (continued)	Northern Pike	N, X		N	X	M, F			N, X
Cyprinidae	Blacknose Dace					M, F, U			
	Blacknose Shiner	N				M			
	Bluntnose Minnow	N	X	N	X	M , F			N
	Common Carp			N		M, F			N
	Common Shiner			N		M, F			
	Creek Chub					M, F			
	Emerald Shiner								
	Fathead Minnow						N, X		
	Golden Shiner								
	Hornyhead Chub		X	N		M, F			
	Lake Chub					U			
	Longnose Dace								
	Mimic Shiner					F			
	Northern Redbelly Dace						N, X		
	Rosyface Shiner					M, F			
	Sand Shiner		X	N	N, X	F			N, X
	Spottail Shiner		X	N		F			X

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M^1 = MDNR (1965), M^2 = MDNR (1974), M^3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Deer Lake	Lower Platte	Loon Lake	Mud Lake	Platte Lakes	Hidden Pond	Hatt Pond	North Bar Lake
Catostomidae	Shorthead Redhorse			X		M			
	Silver Redhorse		U			M			
	White Sucker			N		M, F			
	Longnose Sucker					M, F			
Ictaluridae	Black Bullhead								
	Brown Bullhead	N		N		M, U			
	Yellow Bullhead					M			
Fundulidae	Banded Killifish				X				N
Atherinidae	Brook Silversides								N
Gasterosteidae	Brook Stickleback					M, F	X		
	Ninespine Stickleback								
Cottidae	Slimy Sculpin					M, U			
	Mottled Sculpin					M, F			
Centrarchidae	Black Crappie	N							
	Bluegill	N		N	N, X	M, F	N		N
	Green Sunfish								
	Largemouth Bass	N, X		N	N, X	M, F			N
	Longear Sunfish					M, U			N, X
	Pumpkinseed	N		N, X	N	M, F	N		N

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M^1 = MDNR (1965), M^2 = MDNR (1974), M^3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Deer Lake	Lower Platte	Loon Lake	Mud Lake	Platte Lakes	Hidden Pond	Hatt Pond	North Bar Lake
Centrarchidae	Rock Bass	N		N, X	X	M, F			N
(continued)	Smallmouth Bass			N	X	M, F			N, X
Percidae	Blackside Darter								
	Fantailed Darter								
	Iowa Darter	X			N	F			
	Johnny Darter			N	X	F			N, X
	Log Perch					M, F, U			
	Walleye			N		M			
	Yellow Perch			N		M, F			N, X
Gobiidae	Round Goby								

Appendix I. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M^1 = MDNR (1965), M^2 = MDNR (1974), M^3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Round Lake	Rush Lake	Florence Lake	Lake Manitou	Beck Pond	Taylor Lake	Long Lake	Esch Rd Pond
Petromyzontidae	American Brook Lamprey		Not Sampled in 2003-06				No Fish Observed		No Fish Observed
	Chestnut Lamprey								
	Lamprey, Ichthyomyzon sp								
	Sea Lamprey								
	Silver Lamprey								
Lepidostidae	Longnose Gar								
Amiidae	Bowfin								
Clupeidae	Alewife								
Salmonidae	Brook Trout								
	Brown Trout				C				
	Lake Trout								
	Rainbow Trout								
	Chinook Salmon								
	Coho Salmon								
	Lake Whitefish								
	Lake Herring								
Osmeridae	Rainbow Smelt								
Umbridae	Central Mudminnow								
Esocidae	Muskellunge								

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M^1 = MDNR (1965), M^2 = MDNR (1974), M^3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Round Lake	Rush Lake	Florence Lake	Lake Manitou	Beck Pond	Taylor Lake	Long Lake	Esch Rd Pond
Esocidae (continued)	Northern Pike		X	N, L, G			No Fish Observed	N	No Fish Observed
Cyprinidae	Blacknose Dace		Not Sampled in 2003-06						
	Blacknose Shiner	X							
	Bluntnose Minnow	N, X			N			N	
	Common Carp								
	Common Shiner								
	Creek Chub								
	Emerald Shiner								
	Fathead Minnow	N							
	Golden Shiner	X	X					N	
	Hornyhead Chub								
	Lake Chub								
	Longnose Dace								
	Mimic Shiner								
	Northern Redbelly Dace								
	Rosyface Shiner								
	Sand Shiner	N, X						N	
	Spottail Shiner								

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M^1 = MDNR (1965), M^2 = MDNR (1974), M^3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Round Lake	Rush Lake	Florence Lake	Lake Manitou	Beck Pond	Taylor Lake	Long Lake	Esch Rd Pond
Catostomidae	Shorthead Redhorse		Not Sampled in 2003-06				No Fish Observed		No Fish Observed
	Silver Redhorse								
	White Sucker	N, X			N, L	N			
	Longnose Sucker								
Ictaluridae	Black Bullhead								
	Brown Bullhead								
	Yellow Bullhead								
Fundulidae	Banded Killifish	N, X						N	
Atherinidae	Brook Silversides								
Gasterosteidae	Brook Stickleback								
	Ninespine Stickleback								
Cottidae	Slimy Sculpin								
	Mottled Sculpin				L				
Centrarchidae	Black Crappie								
	Bluegill	N	X					N	
	Green Sunfish				N, L	N			
	Largemouth Bass	N, X						N	
	Longear Sunfish								
	Pumpkinseed	N	X					N	

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M^1 = MDNR (1965), M^2 = MDNR (1974), M^3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Round Lake	Rush Lake	Florence Lake	Lake Manitou	Beck Pond	Taylor Lake	Long Lake	Esch Rd Pond
Centrarchidae	Rock Bass	N	Not Sampled in 2003-06				No Fish Observed	N	No Fish Observed
(continued)	Smallmouth Bass	N		N, L, G	N, L, C			N	
Percidae	Blackside Darter								
	Fantailed Darter								
	Iowa Darter		X	N, L, G	N, L			N	
	Johnny Darter	N, X						N	
	Log Perch							N	
	Walleye								
	Yellow Perch	N, X		N, L, C	N, L, C			N	
Gobiidae	Round Goby								

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M^1 = MDNR (1965), M^2 = MDNR (1974), M^3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Peterson Rd Pond	Good Harbor Creek	Aral Springs	Boekeloo Rd Ponds	Good Harbor Bay	Sleeping Bear Bay	Bar Lakes Shoreline	Esch Road Shoreline
Petromyzontidae	American Brook Lamprey	No Fish Observed							
	Chestnut Lamprey								
	Lamprey, Ichthyomyzon sp								
	Sea Lamprey								
	Silver Lamprey								
Lepidostidae	Longnose Gar								
Amiidae	Bowfin								
Clupeidae	Alewife					N, X	N, X	N	N, X
Salmonidae	Brook Trout			N					
	Brown Trout								
	Lake Trout								
	Rainbow Trout								
	Chinook Salmon					N		N	N
	Coho Salmon								
	Lake Whitefish					N		N	N
	Lake Herring						X		
Osmeridae	Rainbow Smelt								
Umbridae	Central Mudminnow		N	N	N				
Esocidae	Muskellunge								

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M^1 = MDNR (1965), M^2 = MDNR (1974), M^3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Peterson Rd Pond	Good Harbor Creek	Aral Springs	Boekeloo Rd Ponds	Good Harbor Bay	Sleeping Bear Bay	Bar Lakes Shoreline	Esch Road Shoreline
Esocidae (continued)	Northern Pike	No Fish Observed							
Cyprinidae	Blacknose Dace								
	Blacknose Shiner								
	Bluntnose Minnow		N						X
	Common Carp								
	Common Shiner								
	Creek Chub								
	Emerald Shiner					N		N	
	Fathead Minnow								
	Golden Shiner								
	Hornyhead Chub								
	Lake Chub								
	Longnose Dace					N, X	N, X		
	Mimic Shiner								
	Northern Redbelly Dace		N						
	Rosyface Shiner								
	Sand Shiner					N		N	N
	Spottail Shiner					N, X	X	N	N

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M^1 = MDNR (1965), M^2 = MDNR (1974), M^3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Peterson Rd Pond	Good Harbor Creek	Aral Springs	Boekeloo Rd Ponds	Good Harbor Bay	Sleeping Bear Bay	Bar Lakes Shoreline	Esch Road Shoreline
Catostomidae	Shorthead Redhorse	No Fish Observed							
	Silver Redhorse								
	White Sucker								
	Longnose Sucker								
Ictaluridae	Black Bullhead								
	Brown Bullhead		N						
	Yellow Bullhead								
Fundulidae	Banded Killifish		N						N
Atherinidae	Brook Silversides								
Gasterosteidae	Brook Stickleback			N					
	Ninespine Stickleback								
Cottidae	Slimy Sculpin								
	Mottled Sculpin			N					
Centrarchidae	Black Crappie								
	Bluegill		N						
	Green Sunfish								
	Largemouth Bass								
	Longear Sunfish								
	Pumpkinseed		N						

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M^1 = MDNR (1965), M^2 = MDNR (1974), M^3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Peterson Rd Pond	Good Harbor Creek	Aral Springs	Boekeloo Rd Ponds	Good Harbor Bay	Sleeping Bear Bay	Bar Lakes Shoreline	Esch Road Shoreline
Centrarchidae	Rock Bass	No Fish Observed							
(continued)	Smallmouth Bass								
Percidae	Blackside Darter								
	Fantailed Darter								
	Iowa Darter								
	Johnny Darter						N		
	Log Perch								
	Walleye								
	Yellow Perch			N					
Gobiidae	Round Goby						N		

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M1 = MDNR (1965), M2 = MDNR (1974), M3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Platte Bay
Petromyzontidae	American Brook Lamprey	
	Chestnut Lamprey	
	Lamprey, Ichthyomyzon sp	
	Sea Lamprey	
	Silver Lamprey	
Lepidostidae	Longnose Gar	
Amiidae	Bowfin	
Clupeidae	Alewife	N, X
Salmonidae	Brook Trout	
	Brown Trout	
	Lake Trout	
	Rainbow Trout	
	Chinook Salmon	N
	Coho Salmon	
	Lake Whitefish	N
	Lake Herring	
Osmeridae	Rainbow Smelt	
Umbridae	Central Mudminnow	
Esocidae	Muskellunge	

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M1 = MDNR (1965), M2 = MDNR (1974), M3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Platte Bay
Esocidae (continued)	Northern Pike	
Cyprinidae	Blacknose Dace	
	Blacknose Shiner	
	Bluntnose Minnow	
	Common Carp	
	Common Shiner	N
	Creek Chub	
	Emerald Shiner	
	Fathead Minnow	
	Golden Shiner	
	Hornyhead Chub	
	Lake Chub	
	Longnose Dace	N
	Mimic Shiner	
	Northern Redbelly Dace	
	Rosyface Shiner	
	Sand Shiner	N
	Spottail Shiner	N, X

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M1 = MDNR (1965), M2 = MDNR (1974), M3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Platte Bay
Catostomidae	Shorthead Redhorse	
	Silver Redhorse	
	White Sucker	
	Longnose Sucker	
Ictaluridae	Black Bullhead	
	Brown Bullhead	
	Yellow Bullhead	
Fundulidae	Banded Killifish	
Atherinidae	Brook Silversides	
Gasterosteidae	Brook Stickleback	
	Ninespine Stickleback	
Cottidae	Slimy Sculpin	
	Mottled Sculpin	
Centrarchidae	Black Crappie	
	Bluegill	
	Green Sunfish	
	Largemouth Bass	
	Longear Sunfish	
	Pumpkinseed	

Appendix I continued. Summary of fishery surveys in all waterbodies of Sleeping Bear Dunes National Lakeshore. N = NPS Survey (2003/04/05/06), X = Sea Grant Survey (1979), F = USFWS (Sea Lamprey Control), M = MDNR (Unknown Date), M1 = MDNR (1965), M2 = MDNR (1974), M3 = MDNR (1970), L = Lagler (unpublished field notes), G = Ganon and Stockwell (1978), C = Charles (1975), O = Other Reports, U = University of Michigan Dept of Zoology.

Family	Species	Platte Bay
Centrarchidae	Rock Bass	
(continued)	Smallmouth Bass	
Percidae	Blackside Darter	
	Fantailed Darter	
	Iowa Darter	
	Johnny Darter	N
	Log Perch	
	Walleye	
	Yellow Perch	N
Gobiidae	Round Goby	N

Appendix J. Common and scientific names of fishes reported. N = native, I = introduced.

Common Name	Scientific Name	Origin
Lamprey	**Petromyzontidae**	
American brook lamprey	*Lampetra appendix*	N
Chestnut lamprey	*Ichthyomyzon castaneus*	N
Sea lamprey	*Petromyson marinus*	I
Silver lamprey	*Ichthyomyzon unicuspis*	N
Gar	**Lepidostidae**	
Longnose gar	*Lepisosteus osseus*	N
Bowfin	**Amiidae**	
Bowfin	*Amia calva*	N
Herring and Shad	**Clupeidae**	
Alewife	*Alosa pseudoharengus*	I
Trout, Salmon, Char, and Whitefish	**Salmonidae**	
Brook trout	*Salvelinus fontinalis*	N
Brown trout	*Salmo trutta*	I
Chinook salmon	*Oncorhynchus tshawytscha*	I
Coho salmon	*Oncorhynchus kisutch*	I
Lake trout	*Salvelinus namaycush*	N
Rainbow trout	*Oncorhynchus mykiss*	I
Lake Whitefish	*Coregonus clupeaformis*	N
Cisco or Lake herring	*Coregonus artedi*	N
Smelt	**Osmeridae**	
Rainbow smelt	*Osmerus mordax*	I
Mudminnow	**Umridae**	
Central mudminnow	*Umbra limi*	N
Pike	**Esocidae**	
Northern pike	*Esox lucius*	N
Muskellunge	*Esox masquinongy*	N
Minnows	**Cyprinidae**	
Blacknose dace	*Rhinichthys obtusus*	N
Blacknose shiner	*Notropis heterolepis*	N
Bluntnose minnow	*Pimiphales notatus*	N
Common carp	*Cyprinus carpio*	I
Common shiner	*Luxilus cornutus*	N
Creek chub	*Semotilus atromaculatus*	N
Emerald shiner	*Notropis atherinoides*	N
Fathead minnow	*Pimiphales promelas*	N
Golden shiner	*Notemigonus crysoleucas*	N
Hornyhead chub	*Nocomis bigutatus*	N
Lake chub	*Couesius plumbeus*	N
Longnose dace	*Rhinichthys cataractae*	N
Mimic shiner	*Notropis volucellus*	N
Northern redbelly dace	*Phoxinus eos*	N
Rosyface shiner	*Notropis rebellus*	N
Sand shiner	*Notropis stramineus*	N
Spottail shiner	*Notropis hudsonius*	N

Appendix J continued. Common and scientific names of fishes reported.
N = native, I = introduced.

Common Name	Scientific Name	Origin
Sucker	**Catastomidae**	
Longnose sucker	*Catostomus catostomus*	N
White sucker	*Catostomus commersoni*	N
Silver redhorse	*Moxostoma anisurum*	N
Shorthead redhorse	*Moxostoma macrolepidotum*	N
Bullhead and Catfish	**Ictaluridae**	
Black bullhead	*Ameiurus melas*	N
Yellow bullhead	*Ameiurus natalis*	N
Brown bullhead	*Ictalura nebulosus*	N
Killifish	**Fundulidae**	
Banded killifish	*Fundulus diaphanus*	N
Silversides	**Atherinidae**	
Brook silversides	*Labidesthes sicculus*	N
Sticklebacks	**Gasterosteidae**	
Brook stickleback	*Culaea inconstans*	N
Ninespine stickleback	*Pungitius pungitius*	N
Sculpin	**Cottidae**	
Mottled sculpin	*Cottus bairdi*	N
Slimy sculpin	*Cottus cognatus*	N
Sunfish	**Centrachidae**	
Black crappie	*Pomoxis nigromaculatus*	N
Bluegill	*Lepomis macrochirus*	N
Green sunfish	*Lepomis cyanellus*	N
Largemouth bass	*Micropterus salmoides*	N
Longear sunfish	*Lepomis megalotis*	N
Pumpkinseed	*Lepomis gibbosus*	N
Rock bass	*Ambloplites rupestris*	N
Smallmouth bass	*Micropterus dolomieu*	N
Perch	**Percidae**	
Blackside darter	*Percina maculata*	N
Fantail darter	*Etheostoma flabellare*	N
Iowa darter	*Etheostoma exile*	N
Johnny darter	*Etheostoma nigrum*	N
Logperch	*Percina caprodes*	N
Walleye	*Stizostedion vitreum*	N
Yellow perch	*Perca flavescens*	N
Goby	**Gobiidae**	
Round goby	*Neogobius melanostomus*	I

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Great Lakes Inventory and Monitoring Network
2800 Lake Shore Drive East
Ashland, WI 54806

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