Lake Bottom Survey 2009: Torch Lake and Lake Bellaire

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Introduction

The purpose of this survey is to document the lake bottom in order to establish a baseline for future comparison. Studies by the Inland Seas Education Association of Traverse City, Michigan have shown a steady decline in the Lake Michigan population of one particular deep dwelling crustacean, Diporeia affinis[2], commonly referred to as Diporeia. As one of the main food sources for many of the lake's fish, the population of these seemingly unobtrusive "bugs" makes a big difference. Zebra mussels, an invasive species, compete with Diporeia for the same food, mainly zooplankton. This 0.2-0.5 mm long organism is also common in the deep (>80 ft.) inland lakes located just east of the Lake Michigan coastline in Northwest Lower Michigan. In light of the organism's decline in Lake Michigan, concerns have been raised concerning the health and present population levels for Diporeia in the inland lakes, as well as for the effects a Diporeia decline may have on a lake's overall physical condition. The decline of Diporeia and the increase in zebra mussels is very likely linked. About 31 years ago,[3] zebra mussels invaded the Great Lakes and soon afterward Diporeia populations began declining. Zebra mussels arrived in the Elk River Chain of Lakes system about fifteen years ago, but there were no previous quantitative studies of Diporeia populations in these lakes until two years ago. A University of Michigan research team published the last major study on this topic in 1978 that followed a similar study conducted in the 1950's.[4] Neither one of these studies were meant to be quantitative, although they do provide relative densities for a variety of comparable benthic invertebrates.

Now, a new, more aggressive cousin of the zebra mussel, the quagga mussel, has made its appearance in the Great Lakes and the native Diporeia population has decreased still further.[5] One of the reasons may be that quagga mussel can live in areas of the lakes that zebra mussels cannot. Zebra mussels live in the shallower regions of the lake whereas quagga mussels can live in these regions as well as below 30-40 feet in depth where the water temperature is typically about 5 deg. C. Thus, a much larger fraction of the Great Lakes now have quagga mussels and overlap more territory inhabited by Diporeia. Quaggas have not yet arrived in significant numbers in the Elk River Chain of Lakes; and, as in the Great Lakes. We have an opportunity to capture a set of samples of these lakes before quaggas take residence.

This report will document the population density of the Diporeia, zebra mussels, and several other small macro-invertebrates so that when the quagga invades the inland lakes, as it surely will, future surveys can be compared with this data.

Why do we care about the anticipated quagga invasion? One reason is that lake bottoms below about 60 feet are at present relatively barren, except for Diporeia, possum shrimp, and some other smaller zooplankton species. Nevertheless, these creatures are the most significant food source for small deepwater fish, sculpins, burbot, and lake chub, which in turn provide a significant food source for trout populations. Any change in this ancient food chain is likely to cause changes in population of larger fish. Secondly, the lake bottoms are the burial site of most of the phosphorus that enters the lakes. Phosphorus is carried to the bottom by calcium carbonate that precipitates continually during the year and accumulates on the bottom at a rate of about 0.2 mm/yr. Both Torch Lake and Lake Bellaire have significant oxygen levels throughout the year, so this phosphorus never dissolves and is effectively permanently entombed. So, the lake bottoms are effectively covered with fertilizer. If the lake bottoms are altered by significant densities of quagga mussels it is possible that this natural burial process will be disrupted and phosphorus released back into the lakes. The additional phosphorus can cause massive algae blooms. However, these is only two of many changes that might be expected and it is very difficult to predict what other changes might occur in our lakes.

The main purpose of the present report is to document the condition of the lake bottom, specifically the density of both Diporeia and zebra mussels with depth. We expect that the Elk River Chain-of-Lakes will soon be overrun by quagga mussels as they have already been overrun by zebra mussels. This change is expected to mirror a similar change that has already occurred in Lake Michigan. So this study will document the situation before the change.

Diporeia and zebra and quagga mussles

Recent years have seen a downward trend in the number and density of diporeia living in the Great Lakes basin and a dramatic increase in zebra mussels. Studies by the Inland Seas Education Association of Traverse City, Michigan have shown a steady decline in the Lake Michigan population of one particular deep dwelling crustacean, Diporeia affinis.[6] Commonly referred to as Diporeia. This 0.2-0.5 mm long organism is also common in the deep (>80 ft.) inland lakes located just east of the Lake Michigan coastline in northwest lower Michigan. In light of the organism's decline in Lake Michigan, concerns have been raised concerning the health and present population levels for Diporeia in neighboring lakes, as well as for the effects a Diporeia decline may have on a lake's overall physical condition. The decline of diporeia and the increase in zebra mussels is very likely linked since both species eat the same food, namely zooplankton.

To determine if a pronounced decline in Diporeia is occurring in northwest lower Michigan's inland lakes, initial amounts of these organisms must be known. Unfortunately, few published scientific records concern living in Michigan inland lakes. [7,8,9,10,11,12,13] A University of Michigan research team published the last major study on this topic in 1978 that followed a similar study conducted in the 1950's.[14] Neither one of these studies were meant to be especially quantitative, although they do provide relative densities for a variety of comparable benthic invertebrates. To analyze the current state of benthic invertebrate populations, however, more recent data is necessary. To provide these crucial statistics, the Three Lakes Association and Elk-Skegemog Lakes Association jointly conducted a survey in 2007 to determine the current distribution and density of Diporeia in three of the eight lakes discussed in the 1978 report: Torch Lake, Elk Lake, and Lake Bellaire.[15]

The 2007 TLA report documented Diporeia densities in Lake Bellaire and Torch Lake as follows:

Lake Bellaire – Depths sampled: 45 – 90 ft.\
Number of samples: 5
Average density: 189 m^{-2}
Range of densities: 0 – 450 m^{-2}

Torch Lake - Depths sampled: 38 – 155
Number of samples: 10
Average density: 130 m^{-2}
Range of densities: 0 – 360 m^{-2}

Some zebra mussels were also collected and counted but most samples were taken below 38 feet. These numbers do not accurately represent overall lake population since zebra mussels typically live in shallower water. No zebra mussels were found in Lake Bellaire and all samples were taken below 45 ft. Torch Lake had average of 540 m^{-2} in two Torch Lake samples at 38 and 40 ft and none in deeper water. In fact, both lakes have significantly higher zebra mussel densities in shallower water, but zebra densities were not a major theme of the 2007 report.

The main purpose of this report is to document the present condition of the lake bottom, specifically the density of both diporeia and zebra mussels with depth. We expect that the Elk River Chain-of-Lakes will soon be overrun by quagga mussels as they have already been overrun by zebra mussels. This change is expected to mirror a similar change that has already occurred in Lake Michigan. So this study will document the situation before the change.

Method

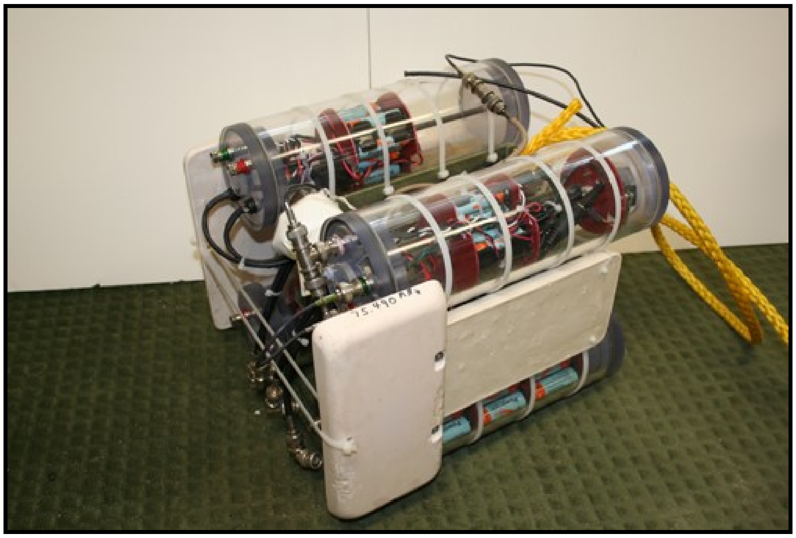
The information used in this report was obtained by multiple samples from Torch Lake and Lake Bellaire in June, July, and August of 2009. All samples were taken between 8 AM and noon. Three Lakes Association's summer interns used boats for weekly excursions. In the lakes we were able to use a PONAR dredge to collect samples for examination. The dredge and sampling technique was borrowed from the Inland Seas Educational Association[16] where it has been used for many years.

The PONAR dredge is a metal device designed to collect sediment and clays that exist on the bottom of bodies of water. Each sample consisted of approximately 0.022 m^2 of sediment, based on the dimensions of the dredge mouth. This device is used widely for lake sampling

PONAR Dredge

The dredge was used to find the benthic invertebrates that were counted and identified. During the research outings the sampling position was recorded with a GPS (Global Position Sensor) and the depth was measured either with a tape or sonar depth gauge. All information was written on the sample bottles for identification and separately in a paper log. We lowered the dredge to the bottom of the lakes with a rope. Once the dredge reached the bottom, slack was given on the rope for the self-releasing pin to fall out and the spring-loaded trap to close. When the dredge was pulled back onto the boat it was emptied into a mesh screen (0.6x0.6 mm square openings) to separate the larger organisms, pebbles, and shells from the sediment material. Notable specimens were taken from the screen with tweezers and placed into a sample bottle with 90% alcohol.

The remotely operated miniature submarine with video was constructed and operated by Norton Bretz, Executive Director of TLA. It consists of four acrylic tubes which contain batteries, an RC (Radio Control) receiver, four brushless motors and electronic speed controllers, and a video camera. The apparatus is controlled with a four channel FM Futaba joystick controller[17] using a coaxial line which also carries the video signal to the surface. The video is viewed and recorded directly on a laptop computer using an EasyCap USB video capture device and software.[18]



Remotely Operated Submarine with video

At all sample locations temperature and depth profiles were taken with the Hydrolab.[19] Measurements were made from the surface to the bottom.

Hydrolab

To identify the organisms collected, a dissection (x10 – x40) microscope with a laptop display was used for larger organisms. Pictures of what was seen underneath the microscope were taken.

Results

The sampling yielded the following data, organized by lake. This section includes the location, species, frequency, etc.

The most abundant and pertinent species were Diporeia and zebra mussels. Other macro-invertebrates such as possum shrimp (mysis relicta), mayfly and midge larvae, worms, miscellaneous shells, and other unidentified bugs are noted, but are not central to this research.

Below is a table of the average sizes of the species found. The average was computed by measuring one representative specimen from each lake sample taken.

Average Size of Macro-invertebrates

Average Lengths of Species Collected	
Species	**Length (mm)**
Mayfly larvae	18
Mysis relicta	12
Diporeia	6.9
Midge larvae	15.5

Lake Bellaire Dredge Samples

Lake Bellaire east June 18

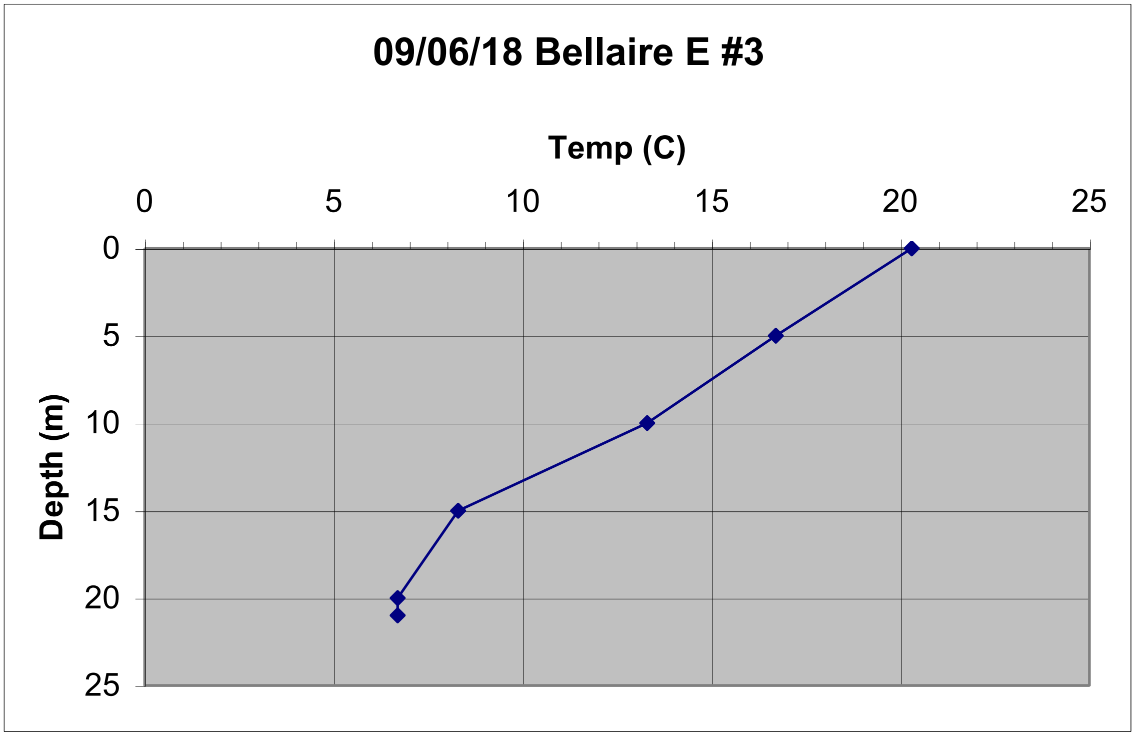
Depth [m]	Location	Bot. Temp. [deg. C]	Dip [#]	Zeb [#]	May [#]	Mid [#]	Mys [#]	Misc. [#]
9.8	N44^{0}56.101' W085^{0}13.339'	13.7	0	2	6	0	0	1 dragon fly larvae
15.5	N44^{0}56.074' W085^{0}13.308	10.2	22	2	1	0	1	
22.0	N44^{0}56.121' W085^{0}13.179’	6.7	57	2	0	3	0	1 worm

Lake Bellaire west July 30

Depth [m]	Location	Bot. Temp. [deg. C]	Dip [#]	Zeb [#]	May [#]	Mid [#]	Mys [#]	Misc. [#]
3.1	N44^{0}57.365' W085^{0}12.957'	22.0	22	~100	0	17	0	2 caddis fly larvae
13.7	N44^{0}57.353' W085^{0}12.981'	11.2	13	19	0	2	0	1 alder fly larvae
20.4	N44^{0}57.315' W085^{0}12.983'	7.1	36	0	0	1	0	

The sample number data may be converted to density by multiplying the number by 53. For example, the first table Diporeia density at 21.9 m is 57x53=3,021 \m^2. Generally, the Diporeia density is higher with increasing depth and the corresponding zebra mussel density is lower with increasing depth. However, the two side of the lake are somewhat different and the total number of samples is small. Whether the difference is due to lack of sunlight (depth) or because of water temperature is not resolved.

Lake Bellaire Temperature Profile



Lake Bellaire Bottom Photos

Bottom of Lake Bellaire East 7/30/09 13.7 m. sandy bottom

Torch Lake Dredge Samples

Torch Lake southeast June 25

Depth [m]	Location	Bot. Temp [deg. C]	Dip [#]	Zeb [#]	May [#]	Mid [#]	Mys [#]	Misc. [#]
9.5	N44^{0}52.943' W085^{0}17.029	12.8	0	10	8	2	0	Sandworm 2 flatworms
21.5	N44^{0}52.973' W085^{0}17.279	9.1	18	1	2	11	0	3 worms
28.7	N44^{0}52.986' W085^{0}17.318'	6.9	49	0	1	3	0	2 worm

Torch Lake southwest July 2

Depth [m]	Location	Bot. Temp. [deg. C]	Dip [#]	Zeb [#]	May [#]	Mid [#]	Mys [#]	Misc. [#]
8.2	N44^{0}52.536' W085^{0}19.115'	11.0	0	0	24	18	0	1Caddis fly larvae 1 alder fly larvae 1 worm
24.4	N44^{0}52.507' W085^{0}19.140'	8.2	0	1	1	36	0	
30.5	N44^{0}52.469' W085^{0}19.124'	6.1	0	0	0	6	0	
64.6	N44^{0}52.522' W085^{0}18.387'	N/A	0	0	0	0	0	

Torch Lake northeast July 9

Depth [m]	Location	Bot. Temp. [deg. C]	Dip [#]	Zeb [#]	May [#]	Mid [#]	Mys [#]	Misc. [#]
10.1	N45°04.091' W085°19.514'	13.9	0	0	1	5	0	None
12.7	N45°04.094' W085°4.564'	10.1	0	0	0	2	0	None
19.8	N45°52.522' W085°18.387'	8.0	0	0	0	0	0	None
30.5	N45°04.077' W085°19.596'	5.8	11	0	0	7	0	None

Torch Lake northwest July 16

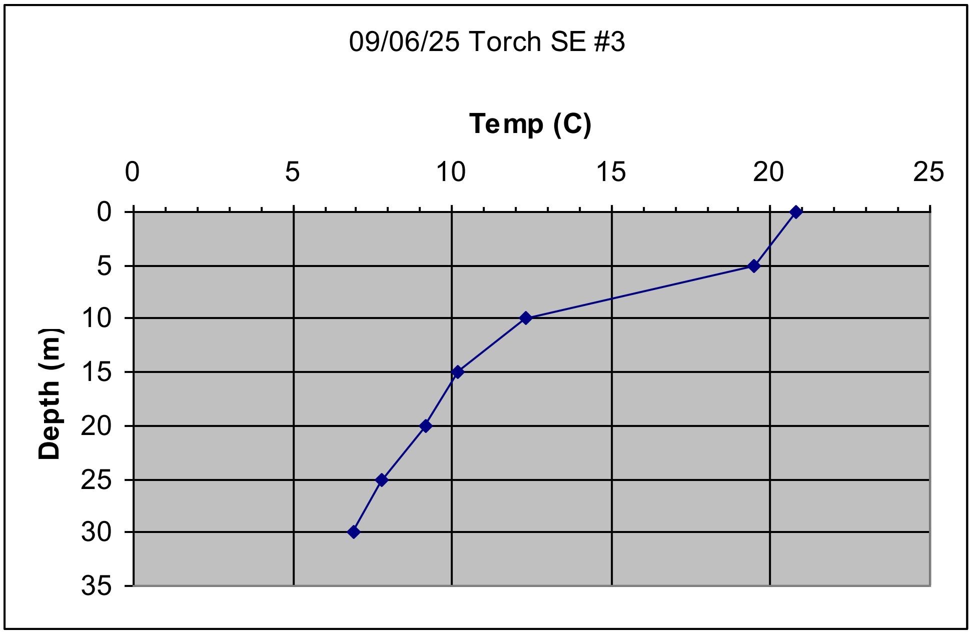
Depth [m]	Location	Bot.Temp. [deg. C]	Dip. [#]	Zeb. [#]	May [#]	Mid [#]	Mys [#]	Misc. [#]
8.2	N45° 04.425’ W85° 20.975	18.4	0	1	0	0	0	Big bug
14.6	N45°04.324' W085°20.947	12.0	0	0	0	0	0	None
18.2	N45°04.369' W085°20.852'	6.9	0	0	2	0	0	None
36.6	N45°04.320' W085°20.751'	5.9	6	0	0	0	0	None

Torch Lake north Aug. 24

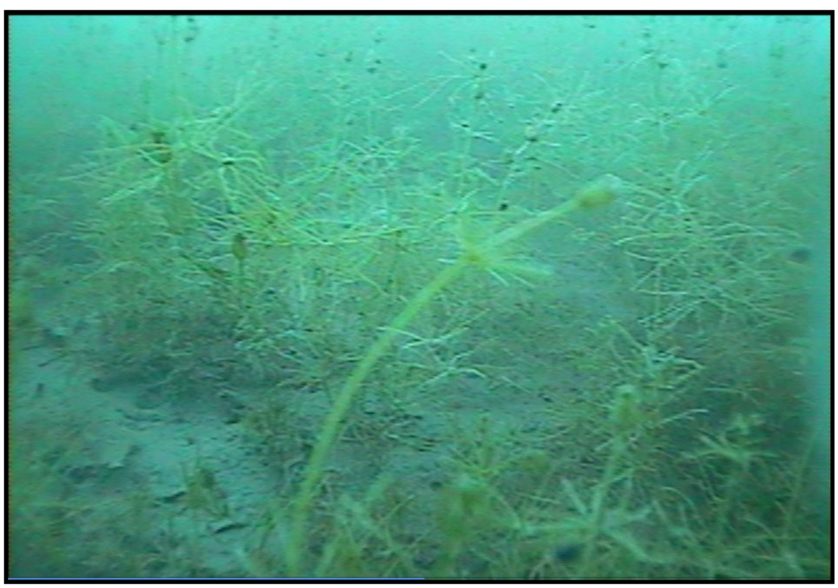
Depth [m]	Location	Bot.Temp. [deg. C]	Dip. [#]	Zeb. [#]	May [#]	Mid [#]	Mys [#]	Misc. [#]
8.2	N45° 06.259’ W85° 20.959	17..3	0	16	3	0	0	Seaweed, fish on video

This data shows the relationship between the water depth, Diporeia sample numbers, and zebra mussel sample number. The Diporeia density increases with increasing depth; and as the water depth decreases the zebra mussel density increases. The first table from southeast Torch Lake is the best example of this relationship.

Torch Lake Temperature Profile



Photos of Torch Bottom



Torch Lake bottom at 8.2 m showing lakegrass over sand

Torch Lake bottom near 8m, showing a perch school

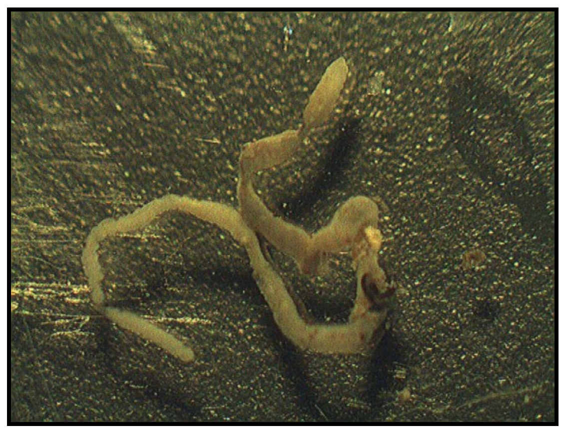
Torch Lake bottom near 8 m, showing bass

Photos of macro-invertebrates from dredge samples

Diporeia

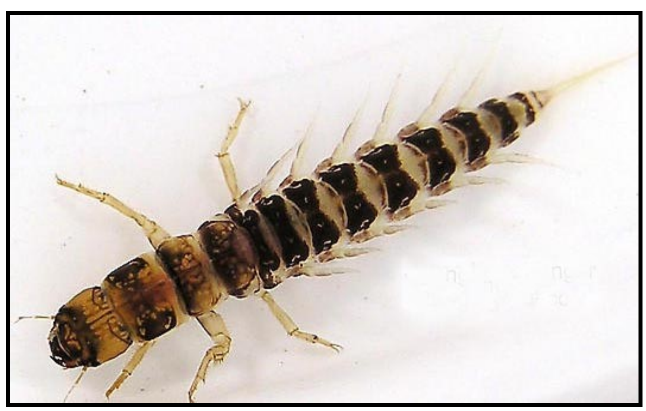
Midge Larva

Mysis Relicta (Possum Shrimp)



Flatworm

Mayfly larva



Alderfly larva

Zebra Mussels Pleurocerca

Discussion

This year we got a picture of Torch Lake and Bellaire Lake before the arrival of the quagga mussel. The quagga mussel is an invasive species that is indigenous to the Dnieper River in Ukraine, which has now overtaken Lake Michigan. Waterborne invasive species are introduced by freighters emptying their ballast water in the Great Lakes. We found zebra mussels and Diporeia in both lakes but the density of the Diporeia were relatively small compared to historic levels in Lake Michigan (>1,000 \m^2). However this year's average densities of Diporeia are much higher than the 2007 densities. We also found zebra mussels, midge, mayfly, dragonfly, alder fly, caddis fly larvae, flatworms, sandworms, and possum shrimp. No quagga mussels were seen in any samples including a survey of mussels on Woodenshoe Beach near Ellsworth on Lake Ellsworth in the upper Chain where some unusual mussel samples had been collected earlier.

Zebra Mussel densities are low in these lakes in comparison with Grand Traverse Bay despite their presence in these lakes for about ten years. The reason for their low population density is still unknown. However, most zebra mussels in the Bay have been replaced by quagga mussels by now whereas all of the shells found in the three lakes in the current study were zebras. Zebra mussels do not readily live on sandy or marl bottoms which appear to predominate these lakes. In the future quagga mussels that do live on sandy substrates and over a larger range of depths than zebras, may well colonize the inland lakes. Quagga larvae, which are invisible to the naked eye, can hitch-hike on the boat bottoms just like zebra mussels.

Data Summary

2007 Diporeia Summary

Lake Bellaire	Torch Lake
Depths sampled: 13.6 – 27.3 m.	Depths sampled: 11.5 – 47.0 m.
Number of samples: 5	Number of samples: 10
Average density: 189 \m^2	Average density: 130 \m^2
Range of densities: 0 – 450 \m^2	Range of densities: 0 – 360 \m^2

2009 Diporeia Summary

Lake Bellaire	Torch Lake
Depths sampled: 3.1 – 22.0 m.	Depths sampled: 8.2 – 64.6 m.
Number of samples: 6	Number of samples: 16
Average density: 1351.5 \m^2	Average density: 590.75 \m^2
Range of densities: 0- 3021\m^2	Range of densities: 318 - 2597 \m^2

2009 Zebra Mussel Summary

Depths sampled: 3.1 – 22.0 m. sample sites: 6	Depths sampled: 8.2 – 64.6 Number of
Average density: 1254.17 \m^2	Number of samples: 16
Range of densities: 106 – 5300 \m^2	Average density: 59.63 \m^2
	Range of densities: 53 – 530 \m^2

Summary

This study provides a snapshot of life on the bottoms of Torch Lake, and Elk Lake, and Lake Bellaire, in 2007. Similar information has not been available since 1978 and little density information is available from any timeframe. Only ongoing studies in Grand Traverse Bay and Lake Michigan give us some information from this time period for comparison.

One of the most important sediment dwelling species is Diporeia. Diporeia was present in all of the lakes studied and at densities that are somewhat lower than in Grand Traverse Bay. Densities are not available from the 1950s and 1975s studies of our lakes for comparison. The largest Diporeia sample was taken from Lake Bellaire where no specimens at all were found in 1975. In general, Diporeia is the dominant species living near the surface of the bottom sediments. Although samples were taken at depths of about 40-60, 80-110 in all lakes and to about 200 ft. in Torch Lake, the number of samples taken in this study and the variation from sample to sample could not determine the distribution of Diporeia with lake depth or temperature.

Another significant difference in these lakes since the 1978 report is the presence of zebra mussels. In the 2007 TLA Glacial Relicts TLA Report only Diporeia were sampled and the sampling was deeper than zebras normally live. In the Great Lakes and Diporeia densities have gone down as the zebra mussels have taken over. However in our lakes, Diporeia densities were somewhat lower in 2007 than those we have observed in 2009. At least during this time period Diporeia have not declined further.

In the present study both Diporeia and zebra mussel densities in the range of 1,000 m^{-2} were found but Diporia dominate below 40 ft. and zebra mussles dominate in shallower and warmer water.

This study was not designed to look for Mysis relicta and only one example was found. In the future sampling can be designed to more effectively search for this species, especially night sampling or tow sampling near the bottom.

Recommendations for future research would include (1) collecting more samples including night sampling and tows near the bottom for Mysis relicta (opposum shrimp), which are similar in size to Diporeia and play a similar role in the food chain, (2) sampling a larger number of sites, and (3) using a higher power microscope and using a systematic protocol for measuring plankton deinsities. Plankton are the main food source of Diporeia, Mysis relicta, and zebra mussels. In fact, dredging and net towing could be separate studies.

Acknowledgement

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