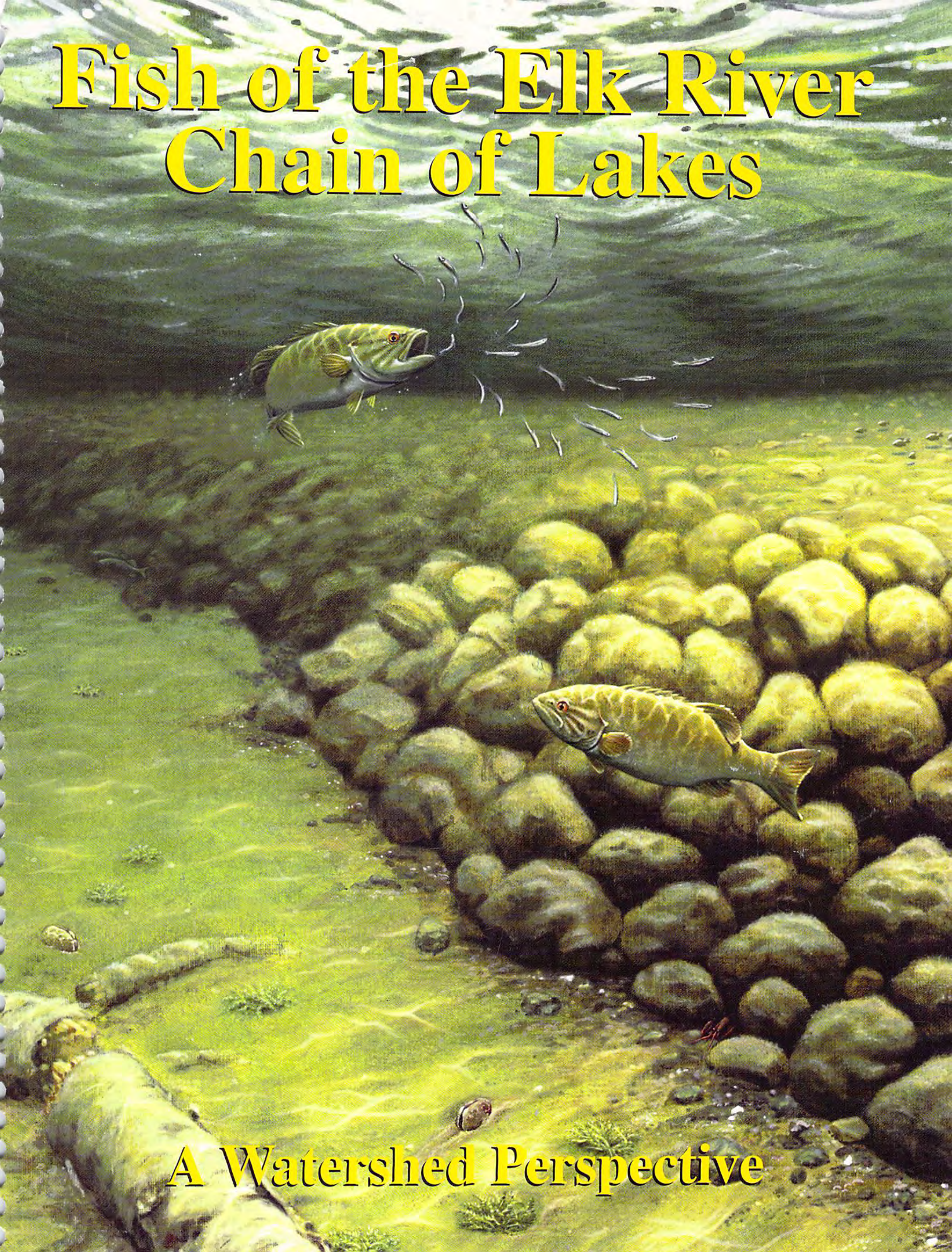
Fish of the Elk River Chain of Lakes



A Watershed Perspective

Fish of the Elk River Chain of Lakes: A Watershed Perspective

Douglas R. Fuller

Tip of the Mitt Watershed Council

Doug Fuller, Tip of the Mitt Watershed Council
426 Bay Street, Petoskey, MI 49770
phone: 231-347-1181 fax: 231-347-5928 e-mail: info@watershedcouncil.org
website: www.watershedcouncil.org

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Table of Contents

Preface

There have been a number of organized efforts to protect and manage the water resources of the Elk River Chain of Lakes Watershed in the last decade. In 1989, the Inland Lakes Management Unit of the Land and Water Management Division of the Michigan Department of Natural Resources (now part of the Department of Environmental Quality) initiated a water resources study funded by the Environmental Protection Agency's Clean Lakes Program, with matching funds from Michigan's Recreation Improvement Fund and Nonpoint Source Pollution Program. The goal of this project, called a diagnostic/feasibility study, was to compile historical and current water quality data on the Elk River Chain of Lakes system to complement the resource protection projects and land use planning activities in the watershed. The results of the project, reported in 1993, indicated that very good to excellent water quality was present, and therefore no major restoration activities were recommended. However, the report recommended some specific, coordinated actions to ensure long-term protection of the water resources of the Elk River Chain of Lakes Watershed.

As a result, the Northwest Michigan Resource Conservation and Development Council (now known as the Conservation Resource Alliance) applied for and received funding through Section 319 of the Federal Clean Water Act to implement many of the actions recommended by the diagnostic/feasibility study. The project ran from Spring, 1995 to Spring, 1998. Specific actions included:

- Voluntary land protection,
- Shoreline protection and landowner education,
- Computer-generated maps for land planning and water resource management,
- Water access site inventory and improvement, and
- Project coordination, evaluation, and leadership training.

Nine organizations and agencies cooperated in the project:

- Antrim Conservation District,
- Antrim County Planning Department,
- Conservation Resource Alliance,
- Elk-Skegemog Association,
- Grand Traverse Regional Land Conservancy,
- Grass River Natural Area,
- Northwest Michigan Council of Governments,
- Three Lakes Association, and
- Tip of the Mitt Watershed Council.

As part of the watershed project, a steering committee was formed to outline other actions needed to shape the future of the project region. Fisheries management concerns were identified as an area of high priority. Specifically, the need to provide better educational information on fisheries resources and management practices was identified.

A concept for an educational publication targeted at Elk River Chain of Lakes property owners, anglers, and other lake and stream recreationalists evolved and funding proposals were developed. Generous funding by the Herbert and Grace Dow Foundation, The Dow Chemical Company Foundation, Ransom Fidelity Company, and the Frey Foundation have made production of this publication possible.

Introduction

Lakes and streams are some of the Earth's most distinctive features. People are attracted to them for many reasons, and one of the biggest reasons has been to go fishing. An estimated 60 million people in the United States fish regularly, and more than 200 million of us (about 82 percent) have fished at one time or another. The reasons for fishing are varied, but relaxation, enjoyment of nature, and social interaction are among the most important. Interestingly, catching large fish, or catching fish for sport or food, are not the most important reasons people fish.

Indeed, sport fishing is an important part of Michigan's and the Nation's economies. Statistics from the American Sportfishing Association show that in 1996 more than 1.8 million anglers took almost 29 million fishing trips in Michigan. In this pursuit they spent an estimated $1.5 billion resulting in about 35,000 jobs. Nationwide, sports anglers currently spend about $24 billion per year, resulting in 925,000 jobs and $70 billion in economic output.

In addition to their recreational significance, fish are an integral ecological component of lakes and streams. In fact, healthy fish populations are crucial for the well being of the aquatic ecosystem. Declining water quality negatively impacts fish populations. In the U.S. it is estimated that 35% of the freshwater fish species are imperiled or vulnerable from pollution or diminished water supplies. And, as more and more research is showing, the degradation of the fish population can contribute to a reduction in water quality.

The main purpose of this publication is to help both anglers and non-anglers (fish-watching, although a little more challenging than bird-watching, can be a fun pastime even for non-anglers), as well as residents and vacationers, to better enjoy the lakes and streams of the Elk River Watershed through understanding the relationship between fish, water quality, and watersheds; and by encouraging the protection of water resources through personal actions and the support of holistic, watershed-based water resource management. If it happens to serve as a useful aid to anglers in enjoying their sport or increasing their catch, then so much the better!

The book is formatted so that each chapter contains a set of stand-alone information. You don't need to read it cover to cover like a novel for it to be useful. If you only want to learn what each lake in the Chain is like, turn to Chapter Five. Or, if that piques your interest in finding out about the life history of the fish that live there, see Chapter Four, and so on. On the other hand, the chapters are arranged in a logical sequence, beginning with the general, basic information needed for an understanding of aquatic systems, and progressing to more specific information about fish ecology and management.

Although the Michigan Department of Natural Resources (MDNR) and other organizations and agencies have done considerable work in the Elk River Chain of Lakes, there has never been a systematic investigation of the fish resources. Consequently, our understanding of the presence, distribution, and ecology of fish in the Chain is far from complete. As someone who spends time in and around the Elk River Watershed, you may have additional knowledge about the fish of the Chain or even observe a species which is not listed as being present. If you come across something interesting, or even troubling, please share it with the Watershed Council, MDNR, or other appropriate resource professionals so we can add to our understanding of the water resources of this fabulous area.

—CHAPTER ONE—
The Elk River Watershed

High hills, densely wooded with northern hardwoods, provide a backdrop to the Skegemog Narrows and serve as a beautiful example of the watershed concept. It is easy to envision rainwater falling on this scenic vantage point flowing down the hill to Elk Lake, while that which falls on the distant moranal hills makes its way to the Skegemog Swamp and Skegemog Lake, nourishing plants, people, and wildlife along the way. Beyond the rim of those distant hills, water flows south toward the Boardman River or north to the Rapid River.

What is a watershed?

A watershed is the geographic area of the land where precipitation drains (or "sheds") to a lake, stream, or wetland (Figure One). Other terms for a watershed include drainage basin and catchment area. The landscape is made up of many interconnected watersheds, so every place on the land is within a watershed.

Just like people or snowflakes, no two watersheds are the same. They all have different sizes, shapes, and other features (such as soils, climate, topography, vegetation, geology, and land use). Since the features of a watershed largely determine the chemical characteristics of the water of the lakes, streams, and wetlands within the watershed, and because no two watersheds are exactly the same, no two water bodies have exactly the same characteristics. Lakes, streams, and the fish that live in them are intricately linked to conditions and activities throughout the whole watershed, and that is why it is important to begin this book with information about watersheds.

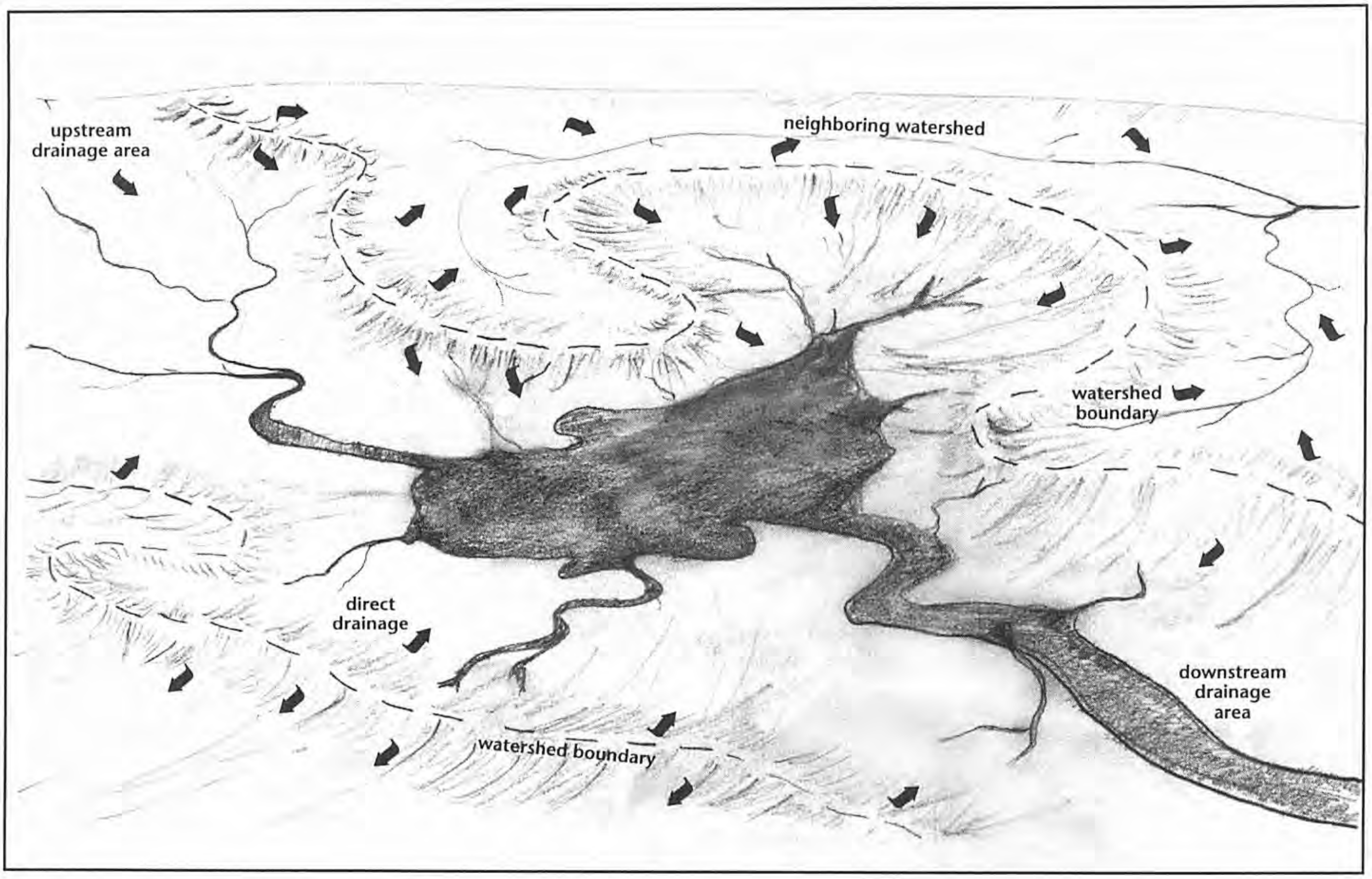


Figure One - The watershed concept. Watershed boundaries are determined by the force of gravity and the elevation of the landscape (water always runs downhill as indicated by arrows). The area from which surface runoff drains to the lake, stream, or wetland (the surface watershed) may be different from the area of ground water drainage (termed the subsurface watershed).

The Elk River Chain of Lakes Watershed

A large watershed, like the Lake Michigan Watershed, is made up of many smaller watersheds, like the Elk River Chain of Lakes (ERCOL) Watershed (Figure Three). The ERCOL Watershed is in turn made up of smaller sub-watersheds, like the Cedar River Watershed (Figure Four).

The ERCOL Watershed covers five hundred square miles of land in Antrim, Charlevoix, Grand Traverse, and Kalkaska Counties. All of the water within this area is draining to the mouth of the Elk River in Elk Rapids. At the centerpiece of the watershed is the Chain of Lakes, a series of 14 lakes and interconnecting rivers. From the uppermost lake in the Chain, the waters flow 55 miles (via the most direct route) and drop 40 feet in elevation on their way to Grand Traverse Bay.

The Chain of Lakes has over 200 miles of shoreline and almost 60 square miles of water. From the stained waters and marshy shores of Beals Lake (smallest and uppermost in the Chain) to the wave-swept, rocky shores of Elk Lake and the large (but short) Elk River, the water resources of the Chain of Lakes are very diverse and generally of high quality. Additionally, more than 200 high quality ground water-fed tributaries (many of which are trout streams, such as the Cedar and Rapid Rivers) flow into the Chain. Another 40 lakes lie within the watershed of the Chain. This is truly one of Michigan's premier watersheds.

Hydrology of the Elk River Watershed

More than half of the 31 inches of precipitation which falls on this watershed in an average year eventually flows down the Elk River. This is a relatively high percentage compared to other watersheds throughout Michigan. It is a direct result of the abundant, permeable, sandy soils, which allow precipitation to soak in and become ground water. The other half is returned to the atmosphere via evaporation and transpiration (see Hydrologic Cycle sidebar). The ground water discharge is responsible for the abundance of trout streams throughout the ERCOL system by providing a relatively stable flow of cold water throughout the summer.

The Elk River's average annual discharge, measured at the dam in Elk Rapids, is 763 cubic feet per second (CFS is a standard unit of measurement for stream discharge). This converts to 5,700 gallons per second, or about 180 billion gallons per year (which is about the same volume as Elk Lake). To give this volume another perspective, it would take 7,375 years for a river of this size to fill a basin the size of Lake Michigan.

Features of the Watershed were Shaped by Ancient Oceans, Lakes, and Glaciers

The ERCOL landscape was created by the glaciers which covered Northern Michigan until 11,600 years ago. As the

The Hydrologic Cycle and Watersheds

To fully understand the concept of a watershed, it is first necessary to know something about the nature and movement of water between the oceans, atmosphere, land surface, lakes, streams, wetlands, and ground water. This movement is termed the hydrologic cycle, and it is driven by energy from the sun (Figure Two).

Water which evaporates from the Earth's surface (primarily from the oceans) blows around the globe as atmospheric water vapor. The water vapor eventually condenses into clouds and comes to earth as precipitation. Once on the ground, a number of things can happen to the water.

It can fall directly into a lake, stream, or wetland, immediately becoming part of that water body. Some of the rain from wetted surfaces and puddles quickly evaporates back into the atmosphere. If rainfall or snowmelt occurs too fast to soak into the soil, water can flow downhill over the land surface. This is called runoff. However, in the Elk River Chain of Lakes (ERCOL) Watershed, much of it soaks into the soil because it is so sandy. Some of the water in the soil is taken up by plant roots and released back into the atmosphere through leaves (called transpiration). Evaporation and transpiration are important losses of water from the land back to the atmosphere.

Water which is not transpired continues moving downward between soil particles, and even through porous rock. This water eventually accumulates at some depth, filling all of the available pore spaces in the soil or rock. This underground accumulation of water is called ground water.

Because of gravitational forces, the ground water moves laterally downslope to the lowest possible elevation. Depending on its rate of movement, water may exist as ground water for a few days or for hundreds of years before discharging to lakes, streams, or wetlands as seepages or springs. Ground water discharge is an important source of water to the lakes and streams of the ERCOL Watershed.

Water which makes its way into the Chain of Lakes flows into Lake Michigan, and then eventually down the St. Lawrence River to the Atlantic Ocean, completing the hydrologic cycle.

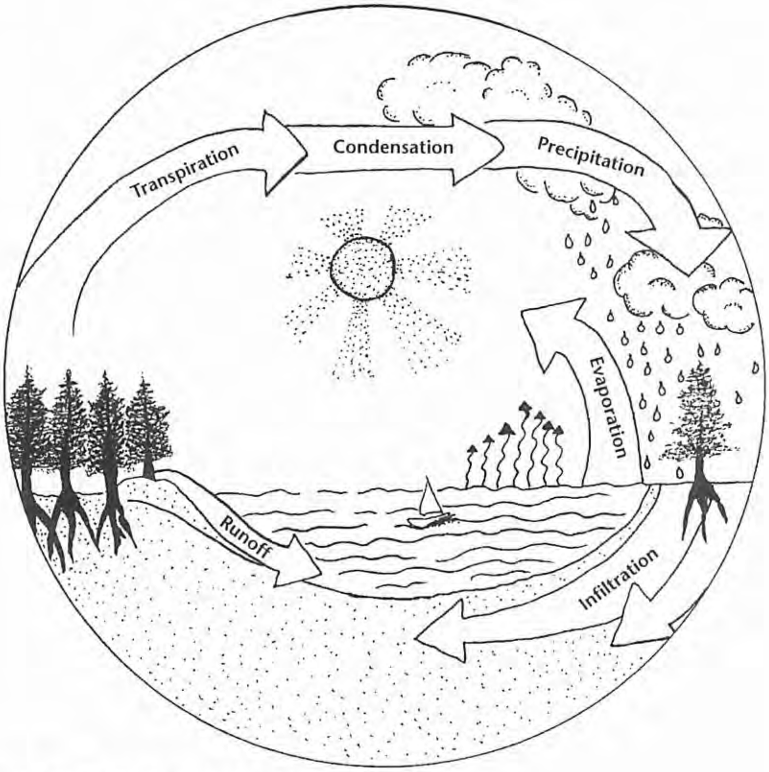


Figure Two - The hydrologic cycle

glaciers melted they left deposits of rock and soil up to 1,000 feet thick on top of shale or limestone bedrock. Deeply scoured valleys and deep depressions created by massive stranded ice blocks eventually filled with water and became the lakes of the Chain (Figure Five).

The high hills and rolling terrain throughout much of the watershed are composed of coarse-textured glacial till (a mixture of boulders, cobbles, gravel, sand, silt, and clay) laid down in formations called moraines. The most common soils in these areas are a mixture of loam (a soil composed of a nearly even mixture of sand, silt, and clay—the three basic types of soil particles) and sand. In the northwest part of the watershed, the till has been formed into unique elongated hills called drumlins.

In the southeast part of the watershed a river with multiple, shifting channels (known as a braided stream) flowed southwest from the front of the melting glacier. It laid down thick deposits of well-washed sand and gravel, a feature called an outwash plain. This large outwash plain (it begins near Elmira in Otsego County and extends in a widening arc south of Traverse City and into Benzie County) is known as the Mancelona Plain in the Antrim County area. Although this glacial river disappeared thousands of years ago, some of the old stream channels (now dry) are still visible. The thick streambed deposits of sand and gravel can be seen at road cuts and construction sites. The Mancelona Plain is the recharge area for the ground water formation (called an aquifer) which supplies the headwaters of the Cedar and Rapid Rivers and the Upper Chain of Lakes.

Many lakeshore areas have sandy or gravelly soils similar to those of the Mancelona Plain. However, these soils were deposited by the actions of lakes rather than streams. Immediately after the glaciers retreated, the waters of what would become Lake Michigan were much higher than the present day lake level, forming an ancient lake called Algonquin by geologists. At that time, much of the Chain of Lakes was a narrow, winding, fjord-like bay of Lake Algonquin extending from the present

Figure Three - Watersheds of Michigan, with the Elk River Chain of Lakes highlighted. Heaviest lines indicate watershed boundaries of the different Great Lakes.

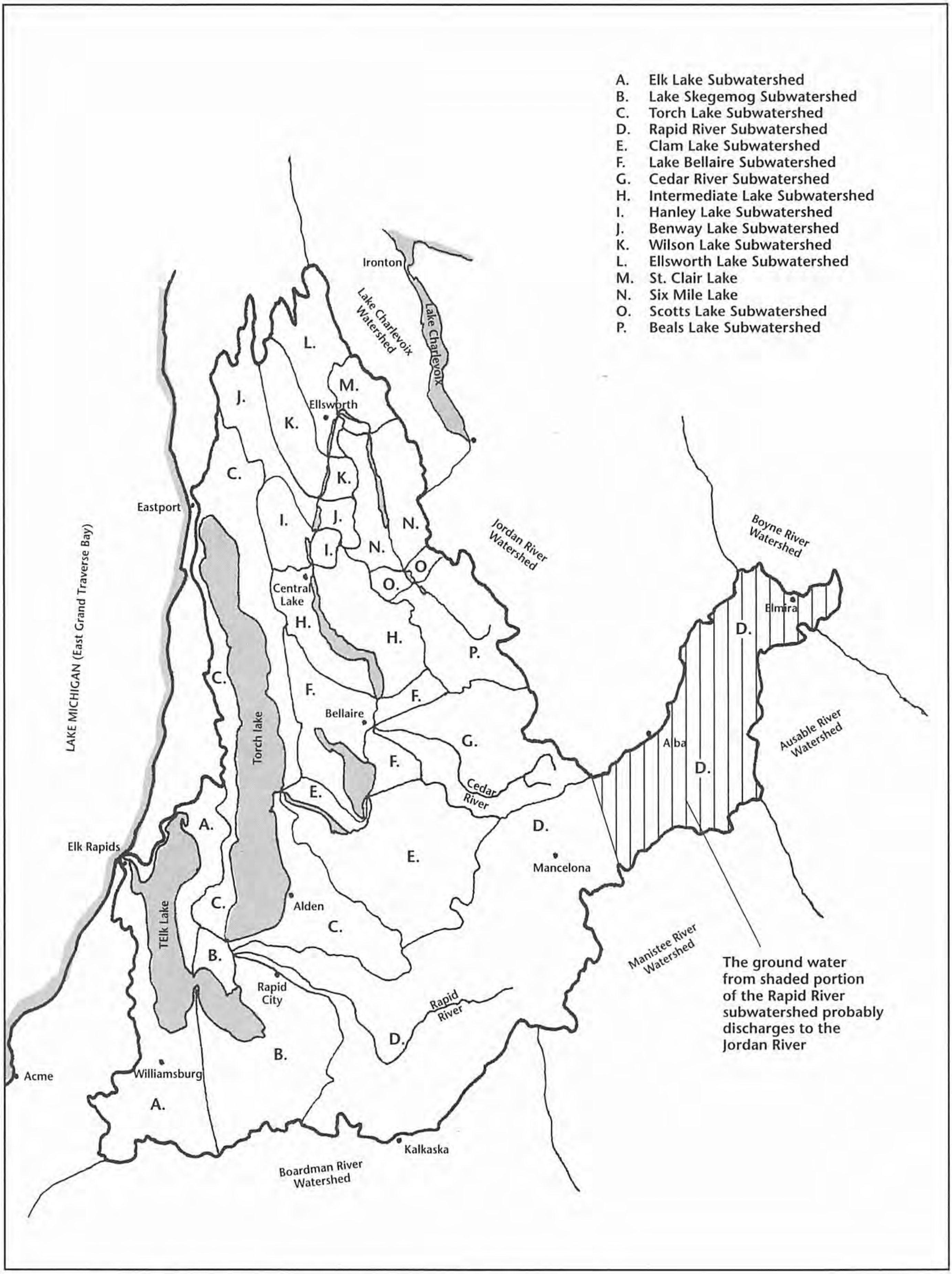


Figure Four - Elk River Chain of Lakes surface watershed and subwatersheds

How Fish Survived the Ice Age

During the ice age, the plants and animals of the region were pushed southward in front of the slowly advancing glacier. Probably most of the species that were present at the start of the ice age survived in compressed climate zones between the end of the ice sheet and the seacoast. No life is thought to have survived beneath the thousands of feet of ice. When the ice melted northward, plants and animals began to spread back to the north, repopulating the barren landscape left by the glacier. Some fish and other aquatic organisms survived in the lake that formed in many places at the front of the glacier. Others followed the many river channels draining away from it. Brian Price and Thomas Kelly, in their 1976 publication *Fishes of the Grand Traverse Region*, explain that species like lake trout, whitefish, cisco, trout-perch, and sculpins came from unglaciated refuge areas to the northwest. The southern Mississippi basin supplied gar, bowfin, suckers, and shiners and other minnows. From both the east and west came pike, perch, darters, dace, and members of the sunfish family. Algae and rooted aquatic plants also became reestablished. The aquatic communities present today eventually developed largely due to the physical and water quality conditions shaped by the glaciers.

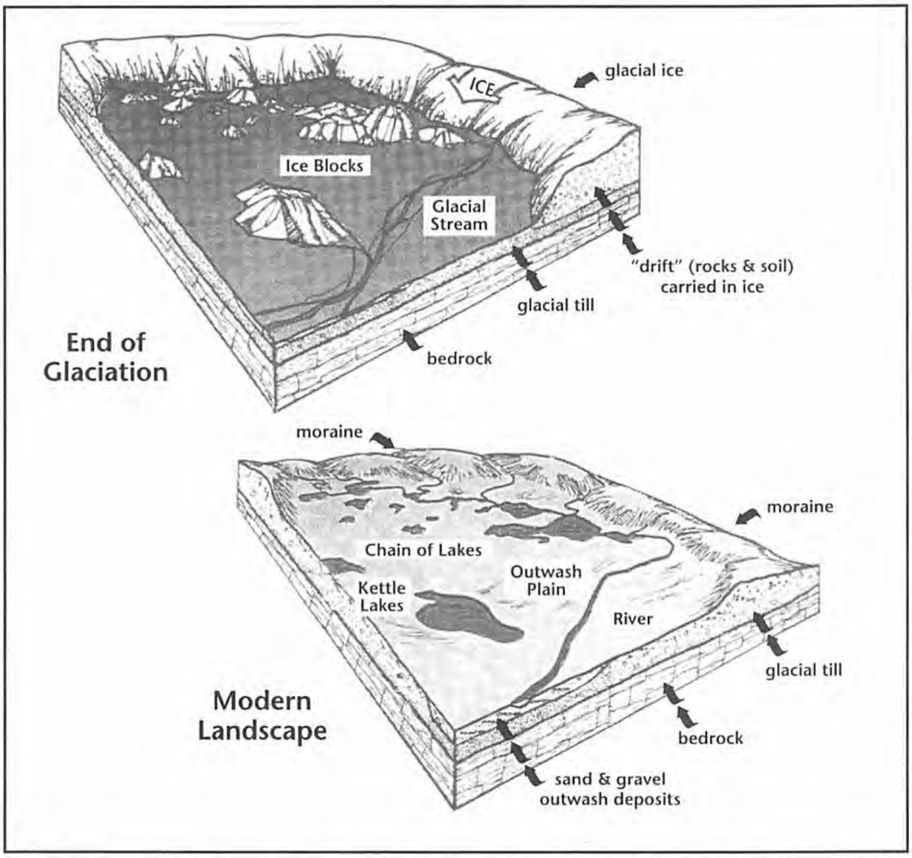


Figure Five - Features of the Chain of Lakes Watershed were created by glacial action.

day location of Elk Rapids and Eastport up to the present day location of Lake Charlevoix. At that time, fish could swim freely between Lake Algonquin and the areas which would become the Chain of Lakes. The waves and currents of this ancient lakeshore (which was 80-some feet higher than the present day lakeshore in the Chain of Lakes area) washed away fine soil particles, leaving a sloping plain (called a terrace) consisting of mostly sand, gravel, rocks, and/or boulders.

The bedrock under the ERCOL Watershed is mostly buried under hundreds of feet of glacial deposits. However, in the vicinity of Ellsworth, greenish-grey shale bedrock lies near the surface and is visible in road cuts and in several quarries (the biggest of which is on the west shore of Ellsworth Lake, see Figure Six). This particular shale is known as Ellsworth Shale. It was formed from sea-floor mud 345 million years ago. It is a weak sedimentary rock, and quickly decomposes to a soil-like consistency when exposed to the weather.

The hills which separate the north end of Torch Lake from nearby Grand Traverse Bay are actually wooded sand dunes which developed on the shores of another precursor of Lake Michigan (called Lake Nipissing) about 5,000 years ago. The ridge-line of these hills forms the surface watershed divide between Torch Lake and the Bay.

Fish, Land Use, and Water Resource Management on a Watershed Basis

There is an inseparable relationship between fish, water quality, and watersheds. The ERCOL Watershed is composed of a long network of rivers, streams, and small intermittent drainages. The flowing surface network is connected to the land by the ground water, which can move long distances. As a result, it is possible for pollutants to reach a water body many miles away.

The geographic area encompassed by the ERCOL Watershed is controlled by many different governmental units. In addition to the four counties, there are fifteen townships, five villages (Bellaire, Central Lake, Elk Rapids, Ellsworth, and Mancelona), and numerous smaller unincorporated communities lying within the

Does Torch Lake's Water Come From Lake Superior?

Occasionally, the claim that "Torch Lake's water comes from Lake Superior," or something similar pertaining to well water, is heard. Perhaps the pure, clear, cold characteristics of the lake (not unlike those of Lake Superior), Lake Superior's higher elevation (about 25 feet higher than Lake Michigan), or the fact that geologic cross-sectional map images show porous sandstone sloping toward the lower peninsula give the impression that Lake Superior waters flow southward underground to this area. However, this is simply a myth.

Aquifers in northern Michigan generally consist of ground water filling tiny spaces between soil and rock particles. The Lake Superior watershed in the eastern upper peninsula is underlain by sandstone which is porous and serves as an aquifer for wells along the Lake Superior Shoreline. The source of the aquifer's water is precipitation. Since the water table under the land's surface is higher than the level of Lake Superior, the ground water flows through the soil and sandstone toward, not away from, the lake.

Most wells in northern Michigan lie in thick glacial deposits. Some wells, and perhaps even the bottom of 300 foot deep Torch Lake, extend to, or below, bedrock. However, the source of water in all these areas is the precipitation which falls within, and moves throughout, their watershed.

Although Torch Lake's water is clear and cold, chemical analysis shows that it is very different from that of Lake Superior (and even significantly different from that of nearby lake Michigan), and that its mineral content is reflective of geological conditions in its watershed. It is virtually impossible that water from Lake Superior could flow in a discreet mass beneath Lake Michigan, cross between numerous rock formations, and come back up to the surface as a spring on the bottom of Torch Lake or in someone's well.

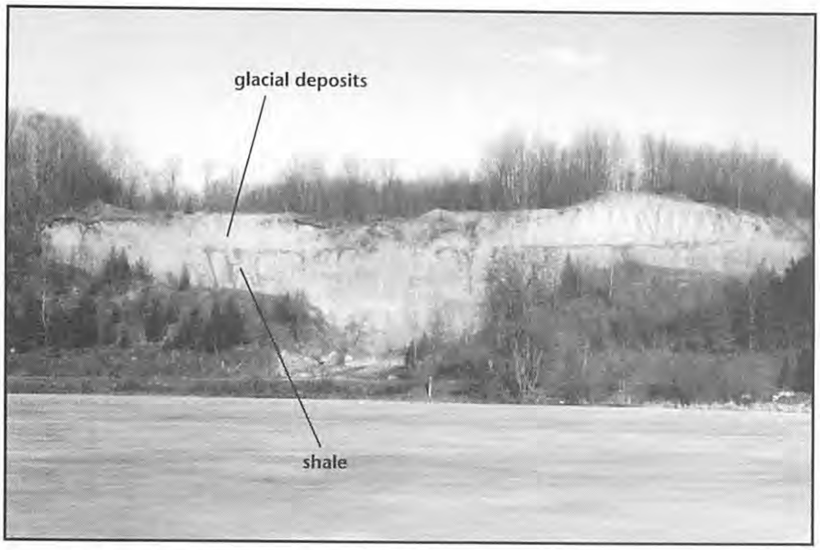


Figure Six - Photo of the Ellsworth Shale Pit

watershed. It is difficult to manage water resources uniformly and consistently across this patchwork of different land use regulations. However, using the watershed as a basic resource management unit is a more effective approach because all water resource related issues (including fish management) for a particular lake or river can be managed as a whole. This approach is becoming increasingly popular. In fact, the Michigan Department of Natural Resources recently adopted a watershed approach for their fish management activities.

The water quality of lakes, streams, and ground water is strongly affected by the type of land use in the watershed. Urban and agricultural land uses produce more runoff and pollutants than undeveloped or forested landscapes. About 78% of the ERCOL Watershed is still in a forested or natural condition (13% of which is wetland or open water). Agriculture accounts for about 18% of the land, and 4% is urban. Although the watershed spans parts of four counties, the majority of the watershed lies in Antrim County. The permanent population of Antrim County was about 18,000 in 1990, with the seasonal population swelling to nearly 50,000 in the summer months. Both permanent and seasonal populations continue to grow in this attractive region.

Shorelines themselves are a special, productive type of habitat found where land and water meet. Because of their attractiveness for development, shorelines are arguably the most endangered habitat type in the United States, and what remains is rapidly disappearing. About 4,150 property parcels are located along the more than 200 miles of shoreline in the Chain of Lakes, more than three-fourths of which are developed.

Everyone lives in a watershed, and many of our daily activities affect the quality of the water downstream, and, consequently, the well being of the animals, birds, and (particularly) fish that live there. Even though the Chain of Lakes is an exceptional watershed, it is not without water resource problems. Improperly functioning septic systems, excessive lawn fertilizing, eroding shorelines, road surface runoff, and wetland destruction are some of the problems associated with developed shorelines. Systematic identification of existing and potential pollution threats throughout an entire watershed is a valuable way to protect water resources. Problems can be corrected or prevented by eliminating the source of pollution, utilizing the best practical resource management practices, better enforcement of existing laws, establishment of new protective regulations, water quality monitoring, and educating people about the need for better stewardship.

Nonpoint Source Pollution

Those pollutants which cannot easily be traced to a particular point of origin are termed nonpoint source or diffuse pollution. Nonpoint source pollution is mostly associated with runoff, but is also delivered via ground water and precipitation. Nonpoint source pollutants include soil particles, pesticides, fertilizers (nutrients), animal and human wastes, disease-causing bacteria, litter, organic materials, heavy metals, oil and grease, road salt, and other toxic materials (Figure Seven).

Specific sources of nonpoint source pollution include:

- fertilizer or pesticide applications to lawn, garden, or cropland,
- use of toxic substances around homes or businesses,
- erosion from construction sites, logging, or agriculture,
- wetland destruction,
- runoff from roads and other impervious surfaces,
- septic systems,
- waste from pets and livestock,
- oil, grease, and exhaust from cars and boats,
- leachate from landfills or salvage, and,
- airborne pollutants from burning and industrial processes.

Nonpoint source pollutants, especially nutrients in lakes and sediment in streams, are the major cause of water pollution in Northern Michigan. Pollution can directly stress or kill individual fish, or hurt populations by causing changes in their habitat. For example, increased sediment inputs to a stream directly reduce the reproductive success of trout.

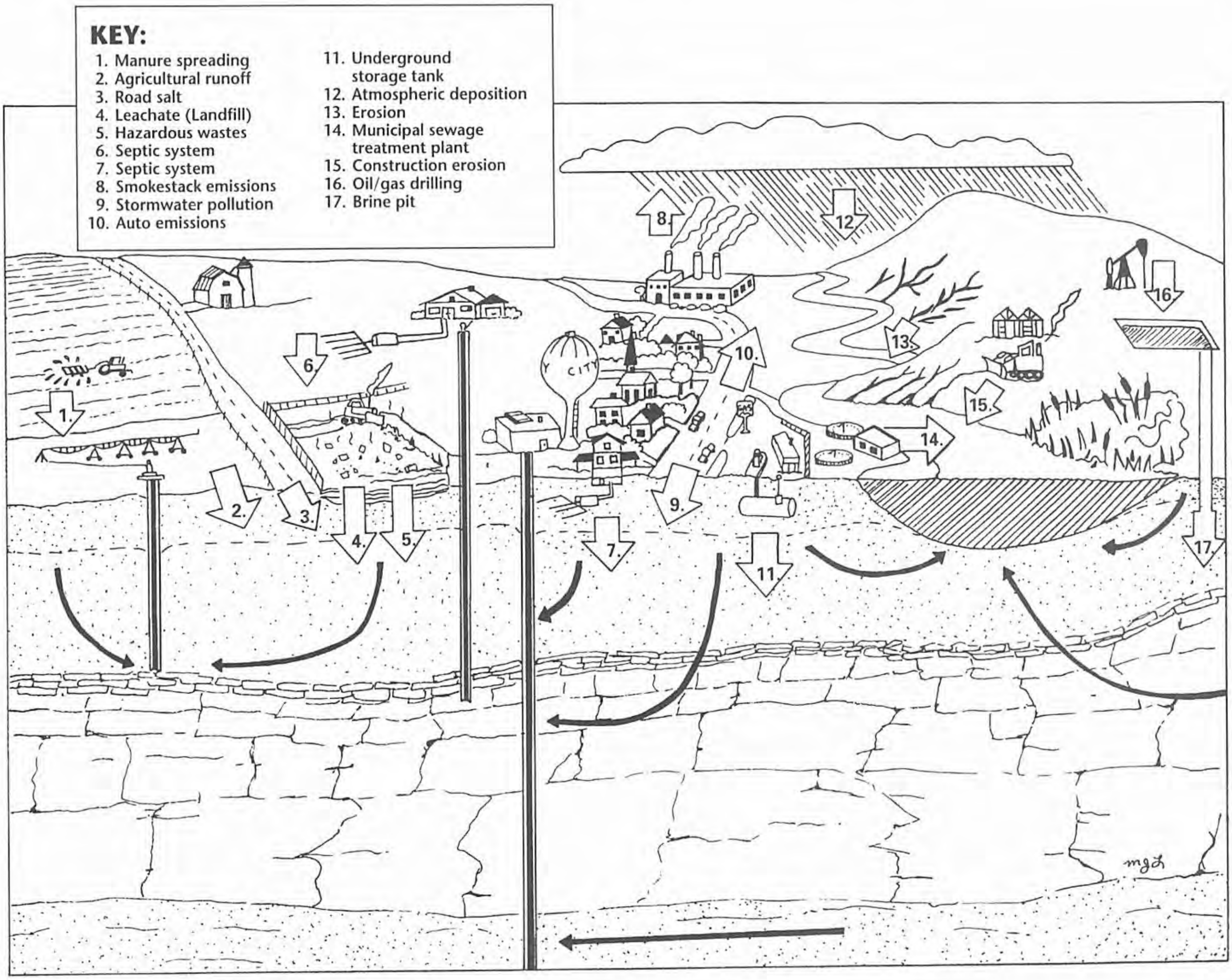
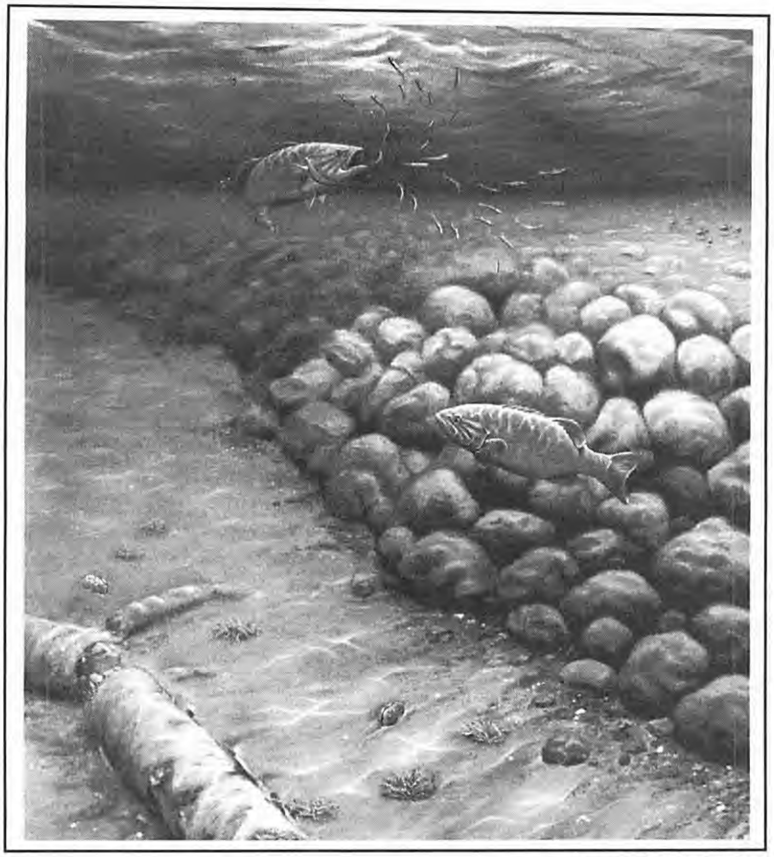


Figure Seven - Examples of nonpoint source pollution.

—CHAPTER TWO—

The Aquatic Ecosystem



Artwork by Larry Tucci

Many components of the aquatic ecosystem are visible in this snorkeler's view of a scene common in Torch or Elk Lake. Along many shorelines, powerful waves have created an underwater terrace of rocks, which are thickly coated with greyish, putty-like marl. At the offshore base of the rocks lies an expansive plain of sand, broken only by scattered logs and scruffy tufts of a branched, filamentous algae called Chara (or muskgrass, for its skunky odor). Freshwater mussels, their hard shells resistant to the abrasive sand, form a tell-tale groove as they move about through the sand filtering microscopic food from the lake water. While the sand is a relatively sterile environment, the rocks provide a good site for the growth of microscopic organisms, and homes for many kinds of aquatic invertebrates that eat them. A pair of smallmouth bass prowl for a meal along the structure provided by the rocks. A crayfish peers out from beneath its daytime rock shelter, safe for now from the bass. Instead of a crayfish, a bass encounters a school of emerald shiners, also seeking food in the warm, productive shallows. Its attack scatters the school in all directions, ensuring that all but one will survive.

What are aquatic ecosystems, and why are they so important to fish?

An aquatic ecosystem is the collection of all the types of living organisms in a waterbody (termed a community) interacting with one another and the nonliving components of their environment. Technically, the aquatic ecosystem encompasses the entire watershed (see Chapter One). From a more practical standpoint, the ecosystem is the fishes' home. Ecosystems are probably complex beyond our ability to understand.

Fish are but one component of the aquatic ecosystem. The physical, chemical, and biological processes of lakes and streams have a direct bearing on the number, type, and size of fish present and the role they play in the aquatic ecosystem. It is impossible to separate them from the rest of the ecosystem, either in terms of management techniques or simply going fishing—their relationship to the ecosystem influences when, where, and how you need to fish for them to be successful. Although many people may consider fish to be the most important component of the ecosystem (and they arguably may be—to us), from an ecological perspective they are of no more importance than the tiniest organisms.

The Aquatic Food Web

Energy (in the form of food) and other substances in an ecosystem move throughout a sequence of different groups of organisms. This is often called a food web because each organism has many web-like links to other organisms. Green plants (including microscopic, single-celled algae; large, visible colonies or filaments of algae; and rooted aquatic plants) form the foundation of the food web. They produce organic matter in the form of new living plant cells and food substances (like fats, sugars, and proteins) through a wondrous process called photosynthesis.

These plants are known as producers. The amount of organic matter and the food they produce is termed production. The rate at which it is produced is termed productivity. Productivity can be likened to a farmer's field producing 80 bushels of corn per acre per year. In addition to productivity from photosynthesis within the waterbody, inputs of organic matter from throughout the watershed (such as leaves blowing, or bugs falling, into the water) contribute to productivity. This outside source of energy is especially important in streams.

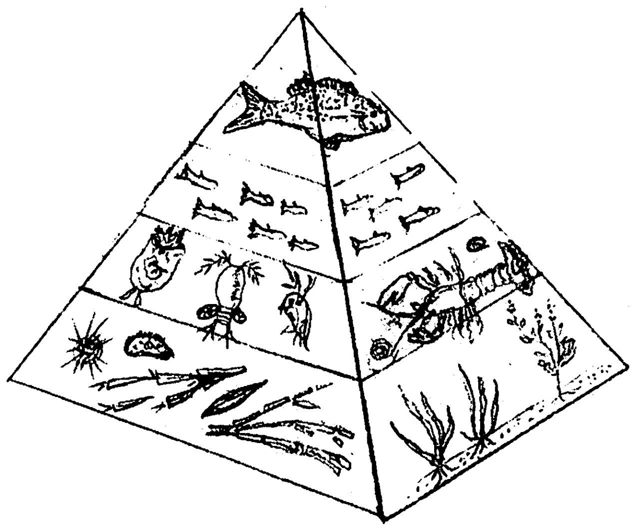


Figure Eight - The food web depicted as a pyramid with representative organisms shown in each basic level.

Unlike green plants, animals cannot produce their own food. For food they rely, either directly or indirectly, on what is produced by plants. These types of organisms are called consumers. Primary consumers are those which directly eat plant material. They include microscopic animals, larger invertebrates, and some fish. The primary consumers are, in turn, eaten by organisms (usually larger) called secondary consumers, and so on up to the biggest predator in the lake or stream. Also part of the food chain are bacteria and fungi which utilize dead or discarded organic matter. These are known as decomposers.

The transfer of energy between strands in the food web is inefficient. In other words, one pound of minnows eaten does not produce one pound of flesh on a bass. Usually, the transfer efficiency is about 10-20%. This means that a relatively small number of sport fish depend on a large number of smaller (forage) fish, which in turn require a huge amount of invertebrates and plankton for food. As a result, the food web is often depicted as a pyramid, with a large amount of primary producers at the base and a few carnivores at the apex (Figure Eight).

However, food webs are never as simple as the figure depicts, but are highly complex. Food web dynamics always change a little year to year, depending on climate conditions and natural cycles of abundance of organisms, but the producers and consumers are generally in balance with each other. For example, if more of a certain type of algae grows, more of the organisms that eat it will be able to survive, eventually reducing the amount of algae to more "normal" levels. However, if one linkage in the food web is drastically changed, like the addition of large amounts of nutrients or the chronic depletion of a certain consumer, the balance between producers and consumers may be upset. In that case, drastic, long-lasting, and often detrimental changes may occur in a lake or stream. A common example is the removal of too many bass or northern pike from a lake, resulting in reduced predation on yellow perch or bluegill, which then become so numerous that none of them can find enough food to grow large. Stunting of panfish most often occurs in small lakes where the few large predators can be most easily caught.

Water Quality

The physical, chemical, and biological characteristics of the water itself are collectively known as water quality. Fish are greatly affected by, and extremely sensitive to, water quality. There can be literally thousands of dissolved substances in the water, of both natural and human origin. Water quality can be measured and described in hundreds of ways. Complete documentation and understanding of the water quality of a lake or stream requires massive expense

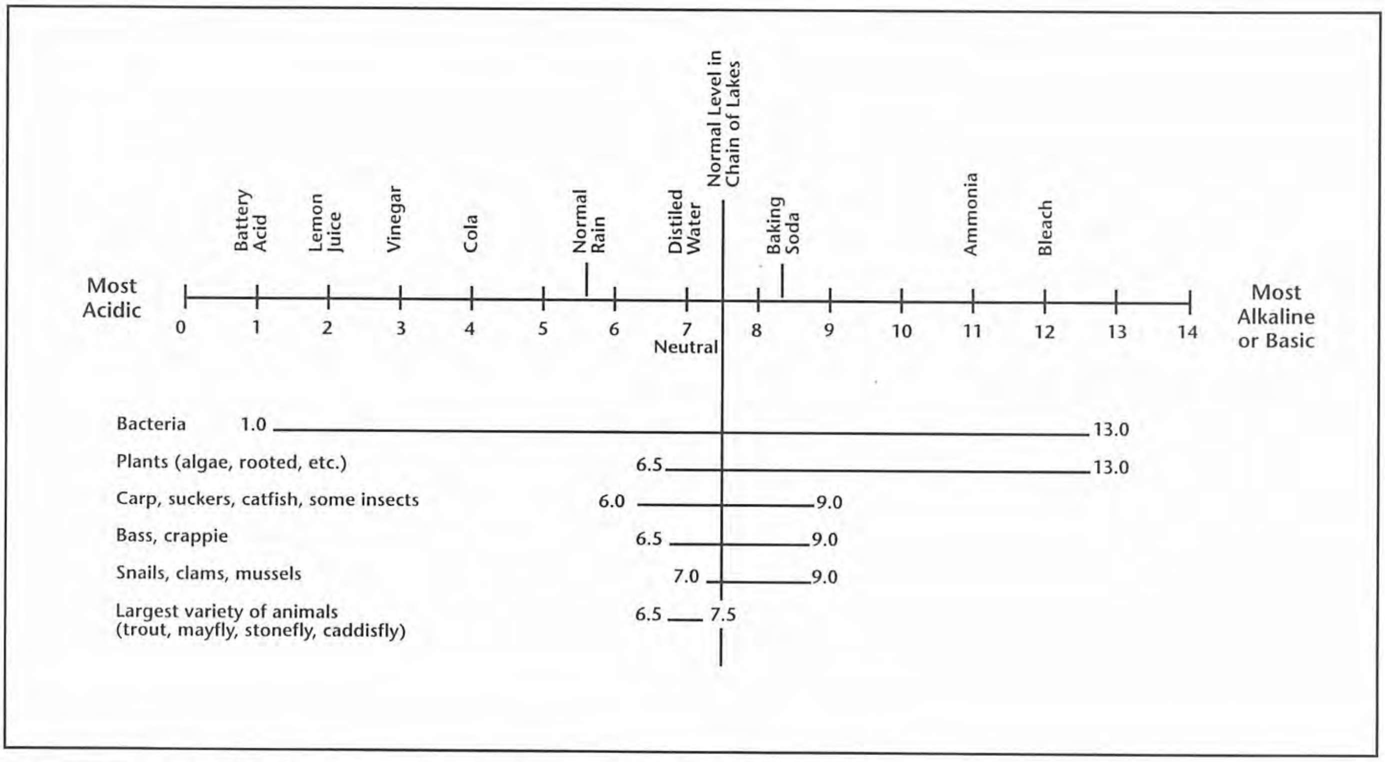


Figure Nine - The pH scale, with reference information and preferred ranges of selected organisms.

Common Water Quality Parameters

pH. pH is a scientific notation for the measurement of the acidity or alkalinity of water. The pH scale ranges from 0-14, with 7 being neutral, levels below 7 indicating acidity, and levels above 7 indicating alkalinity. When pH is outside the range of 5.5 to 8.5, most aquatic organisms become stressed and populations of some species can become depressed or disappear entirely (Figure Nine). Deposition of acidic substances from air pollution is causing many waters around the world to develop dangerously low pH levels. Fortunately, waters of the Chain are alkaline (the pH is usually about 7.6), and are well-buffered against acidification.

Dissolved Oxygen. Oxygen is required by almost all organisms, including those that live in the water. Oxygen dissolves into the water from the atmosphere (especially when there is turbulence) and through the photosynthesis of aquatic plants and algae. There is a maximum limit to the amount of dissolved oxygen (D.O.) the water can hold (called saturation limit), which varies with temperature. The closer the D.O. is to saturation, the better the water quality. Fish and other organisms can recover from short exposure to low D.O., but prolonged exposure to very low levels can permanently harm or kill fish. Generally, cold water fish need higher D.O. levels than warmwater fish, and larval and juvenile fish need higher D.O. levels than adults. Excessive nutrients and the respiration and decay of the plant life they stimulate, as well as some other types of pollution, can consume oxygen faster than it is produced, robbing the water of D.O. See the sidebar on lake stratification for more information on D.O. in lakes.

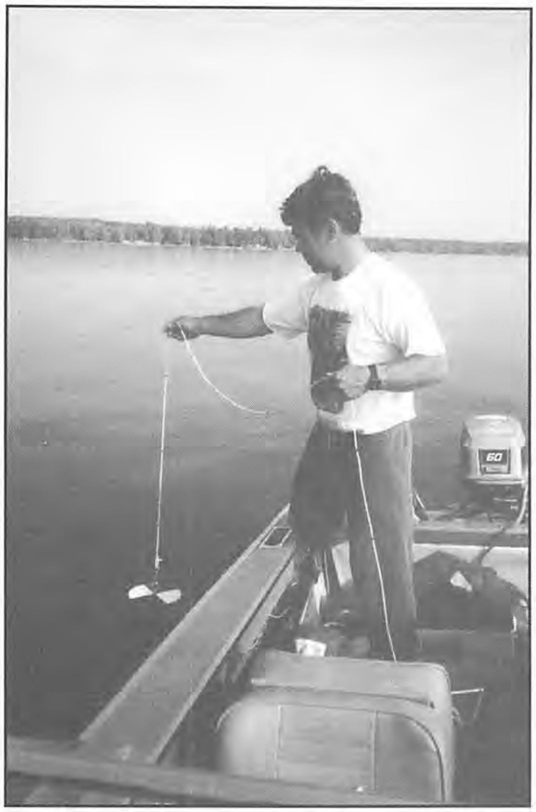
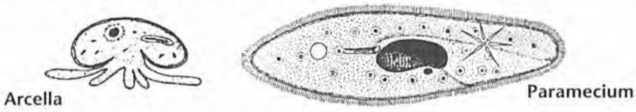


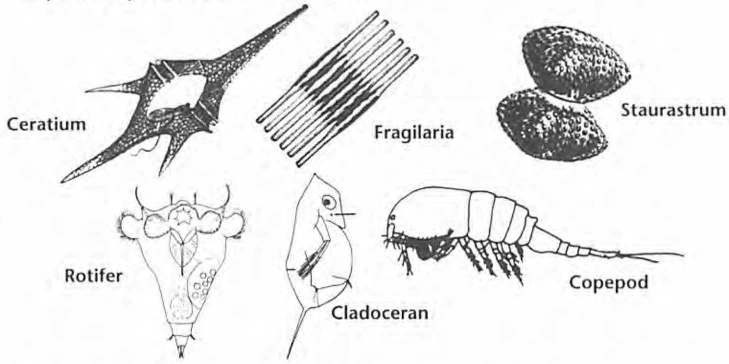
Figure Ten - An eight-inch diameter black and white disk was first used by Italian scientist Pietro Secchi in 1865 to measure water clarity. The Secchi Disk is still widely used today, as demonstrated by the author on Lake Bellaire.

Types of Aquatic Organisms

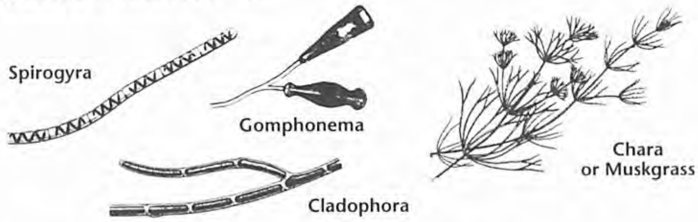
Microbes - Bacteria, fungi, yeast, mold, protozoans and other microscopic organisms that are not capable of photosynthesis. They are most commonly responsible for the decomposition of plants and animals. They provide nutrition to animals that feed on dead organic matter, and are important in the cycling of nutrients.



Plankton - Microscopic plants (phytoplankton), and animals (zooplankton) that live suspended in the water column of lakes and large, sluggish rivers. Some fish eat phytoplankton, but most species eat zooplankton at some point in their life. Phytoplankton are the most important producers in most lakes.

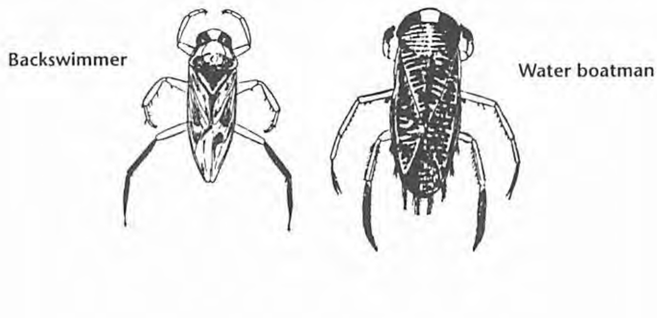


Periphyton - Single-celled, colonial, or filamentous algae living attached to submerged surfaces of plants, rocks, bottom sediments, docks, etc. Few fish feed on periphyton, but some types can provide habitat for small or young fish. Periphyton are the most important producers in most streams.



Benthon - The organisms living on or in the lake or stream bottom, including both plants and animals.

Neuston - All the organisms associated with the water surface. Examples include water bugs, hatching insects, and duckweed.



Common Water Quality Parameters –continued

Water Clarity. The more algae or sediment in water, the less clear it is. Clearness is also described by terms like turbid, cloudy, or muddy. Generally, the clearer the water the fewer the nutrients and sediments and the better the water quality (Figure Ten). Waters which are muddy may be less productive, because sunlight cannot penetrate deeply. Muddy waters also clog fish gills, smother spawning beds, inhibit the sight and feeding of many fishes, and can reduce angling success.

Chlorophyll-a. Chlorphyll-a is a pigment found in all green plants, including algae. Measuring the amount of chlorophyll-a in the water provides a measure of the amount of phytoplankton, which is directly related to nutrient level and primary productivity. See sidebar on Volunteer Lake Monitoring in Chapter Five for more information about water clarity and chlorophyll-a.

Color. Algae, sediments, and other suspended or dissolved materials in the water can impart color as well as turbidity. Suspended sediment (soil particles) causes water to be slightly milky brown to dark chocolate brown, depending on amount and source. Algae can impart a green or yellowish color to the water. Slight brownish or tea-colored staining can be caused by organic compounds from wetlands. Slight staining is often evident where streams discharge into the clearer lakes in the Chain. (See photo on back cover). This staining is not harmful, and should not be confused with sediment pollution. Many lakes in the Chain experience a phenomena called marl turbidity (caused by a chemical precipitate of tiny calcium carbonate particles), which imparts a milky-green color to the water. Very clear, deep waters are generally some shade of blue because that part of the light spectrum is absorbed least by water, and some of the blue light entering the water is reflected back up to the surface (the same principle which makes the sky look blue).

Common Water Quality Parameters -continued

Conductivity. The ability of water to conduct electricity is termed conductivity. The level of conductivity is directly related to the concentration of dissolved substances in the water. Conductivity is an easy and accurate way to measure the level of dissolved substances, but cannot indicate what the substances are. If conductivity levels show a steady increase over a period of years, it may indicate that pollution is occurring, and that further testing may be needed.

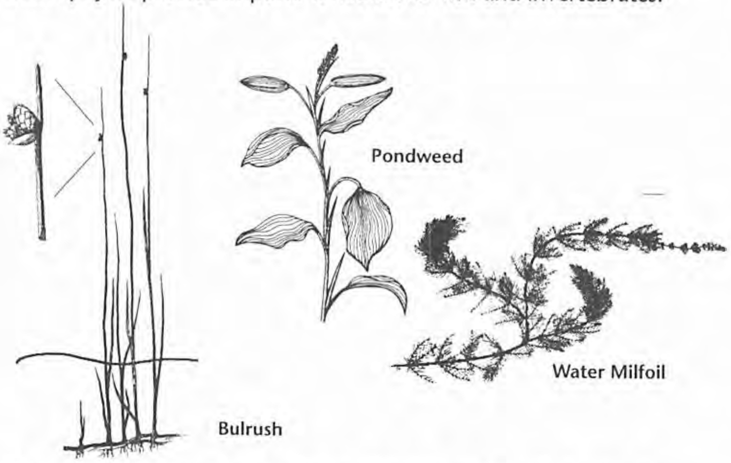
Chloride. Chloride is a component of salt. Due to the marine (salt water) origin of bedrock in Northern Michigan, low levels of chloride are naturally present in the ground water. Chlorides are common in many products associated with human activities. Consequently, elevated or increasing chloride levels can indicate impacts from human activities. Even slight increases in chloride concentration can have a subtle impact on aquatic ecosystems, but most fish and other large aquatic organisms are not directly affected unless concentrations are very high (about four times the level where the water begins to taste salty).

Nutrients. Nitrogen, phosphorus, and carbon are the three nutrients most important for aquatic plants. Phosphorus is the most important nutrient for productivity in surface waters because if it is in short supply, it limits primary production. Nutrients are associated with many human activities, and nutrient pollution (from things such as fertilizer, faulty septic systems, and stormwater runoff) is considered the greatest threat to the ERCOL Watershed. For instance, septic tank effluent contains about 1,500 times as much phosphorus as normal lake water.

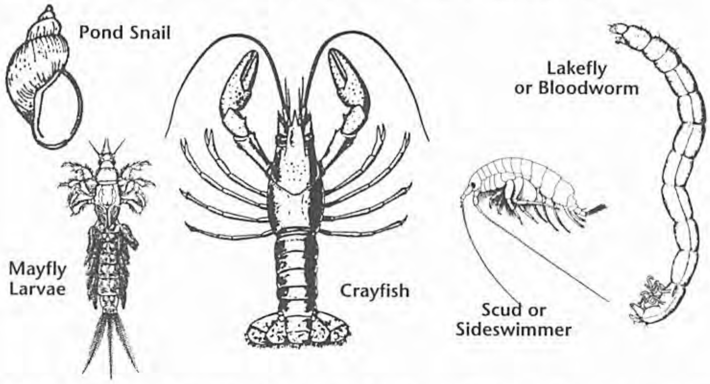
Types of Aquatic Organisms -continued

Nekton - Actively swimming organisms which are able to navigate at will. Fish are the most notable member of this category, but animals such as some insects and water snakes are also included.

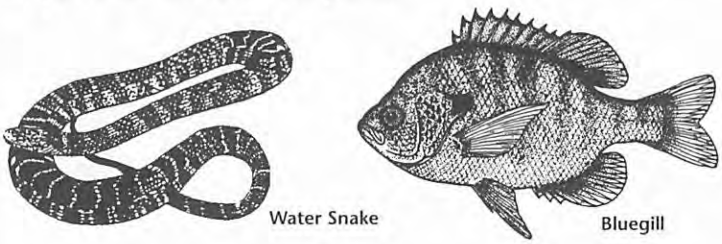
Macrophytes - Large, non-algae aquatic plants which mostly grow rooted in the bottom sediments, but which can be free-floating. They are more commonly called aquatic plants or simply "weeds." Macrophytes provide important habitat for fish and invertebrates.



Macroinvertebrates - The group of larger, multi-celled animals without backbones, including insects, worms, mollusks, and crustaceans. They generally live on the bottom or are attached to macrophytes or woody debris. Aquatic insects are one of the biggest groups of macroinvertebrates. Most aquatic insects are actually terrestrial as adults, but their immature life stages (called larvae) live in the water. These are one of the most important groups in the food chain for fish.



Vertebrates - Animals with a spinal column. Fish are the main aquatic vertebrates. However, other aquatic or water-dependent vertebrates, such as amphibians (frogs and mudpuppies), reptiles (snakes and turtles), birds (ducks and loons), and mammals (beaver and otter), are part of lake and stream ecosystems.



and effort. Fortunately, there are some relatively simple procedures that can be used to reveal basic water quality conditions and trends (see the sidebar about common water quality parameters). Most basic water quality monitoring is designed to characterize conditions in a lake or stream and help reveal any changes over time, rather than identify the sources of pollution. If significant change becomes apparent, then other monitoring programs can be designed to help identify the cause of the problem. Basic monitoring usually categorizes water quality as simply "excellent, good, or bad," depending on how conducive it is for a certain use or activity, or how much it has been degraded by human activities. Most waters in the Elk River Chain of Lakes (ERCOL) Watershed have excellent to good water quality.

Lake Features

The physical features of a lake have an important bearing on the characteristics of its ecosystem, including the makeup of the fish community and its susceptibility to negative impact from development. The following are commonly described physical features. Figure 34 in Chapter Five describes most of these features for each lake of the Chain.

- **Lake size.** The surface area of a lake, usually given in acres or square miles, is probably the feature that people most relate to, especially when comparing different lakes to each other. Volume is a less commonly used, but very important, way to express lake size. Two lakes of the same surface area may contain very different amounts of water if they have different average depths.

- **Maximum and average depth.** Maximum depth is the greatest depth anywhere in the lake. Some lakes have a relatively deep hole, but which covers only a tiny portion of the lake. Comparing average depth to maximum depth can help portray the extent of the deepest areas.

- **Length and width.** Length is the distance along the longest axis of the lake. Often, it is a straight line running entirely over water. However, some lakes (like Intermediate Lake) have a curved shape, so the length is not a straight-line distance. The width is the greatest distance from shore to shore, at a more-or-less right angle to the length axis. The greatest distance over which the wind can blow in a straight line is termed fetch. Fetch is important because it is directly related to the maximum size of waves which can develop on a lake, which in turn influences stratification depth (see the sidebar about stratification), and the type of shoreline and nearshore bottom habitat.

- **Shoreline length.** This is the distance around the lake's perimeter. The length of shoreline relative to the surface area of a lake is variable—a perfectly circular lake will have less shoreline than a lake of the same area but with a more irregular the shoreline (Figure 11). Lakes with relatively long shorelines can have more homes, lawns, septic systems, etc., and more pollution associated with them. They also have a relatively larger area of important nearshore fish habitat.

- **Watershed area.** A watershed is that area of the land which drains to the lake (see Chapter One). For some lakes, watershed area can be subdivided into two types, immediate and overall watershed. The immediate watershed is that area of the land which drains to the lake without first passing through another lake. It is important to differentiate between the two because lakes act as traps for nutrients, sediments, and other materials contributed from throughout the watershed. Therefore, the immediate watershed has the greatest water quality impact on a lake. The watershed to surface area ratio is used as an indicator of susceptibility of a lake to pollution from its watershed. A large ratio means that there is a large area draining to the lake relative to its size, and a generally greater likelihood of pollution.

- **Depth to volume relationship.** This is an expression of the percent of surface area of a lake which is above a certain depth, and can be portrayed using a graph (see Figure 35, Chapter Five). A depth-area graph can help illustrate the relationship between lake basin features and productivity—for example, the percent of the lake where sunlight reaches the bottom.

- **Flushing rate.** The flushing rate is the theoretical amount of time needed for the existing volume of water in a lake to be completely replaced with inflowing water. It is determined by calculating the

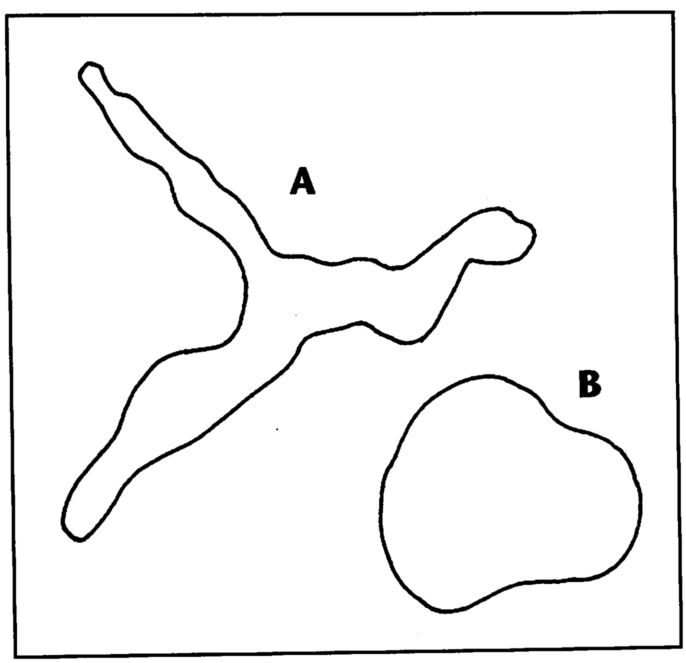


Figure 11 - Two lakes of the same size but with greatly different shapes. Lake A has more than twice as much shoreline as lake B.

discharge of the lake's outlet and dividing it by the lake's volume. In reality, flushing rates are more complex because there are other losses of water from the lake (such as seepage, evaporation, and withdrawal), water does not move evenly through the lake from inlet to outlet, and stream flow varies seasonally. In general, a lake with a fast flushing rate can withstand pollution from shoreline areas with less extensive or long-lasting damage than can a lake with a relatively lower flushing rate. However, lakes with fast flushing rates may be more vulnerable to activities in the watershed.

Ecological Regions of a Lake

Lakes consist of a number of different ecological regions. Each region has different numbers and types of organisms. Figure 12 shows the different ecological regions of a typical lake.

- **Shoreline.** This is the wave-washed boundary between water and land. It is an important, sensitive area with habitat and productivity implications for both fish and water-dependent terrestrial wildlife.

- **Lake surface.** The lake surface is the interface between air and water. Due to the attraction of water molecules to each other, the water's surface develops a tough "film." A lot of bacteria, fungus, pollen, etc. gets caught in the surface film; some types of algae grow at the surface; and some organisms, like water striders and whirligig beetles, have developed specialized mechanisms for living in association with the surface film. Fish can often be seen feeding on insects emerging from the water or which have fallen on the water's surface.

- **Littoral.** That portion of the lake extending from the shore to the depth where light penetrates to the bottom and plants grow is called the littoral zone. The littoral zone may extend throughout a lake if it is shallow and clear. The littoral zone may be subdivided into different regions, depending on which type of plants grow there (such as emergent vegetation, floating leaved plants, or submerged plants).

- **Limnetic or Pelagic.** This is the zone of open water extending from surface to bottom, which is bounded on the shore edge by the littoral zone. It can be subdivided into areas where light penetrates (photic), and, if the lake is deep enough, to the zone where it doesn't (aphotic). The limnetic zone is home to phytoplankton (in the lighted portion), zooplankton, some insects, and open water species of fish.

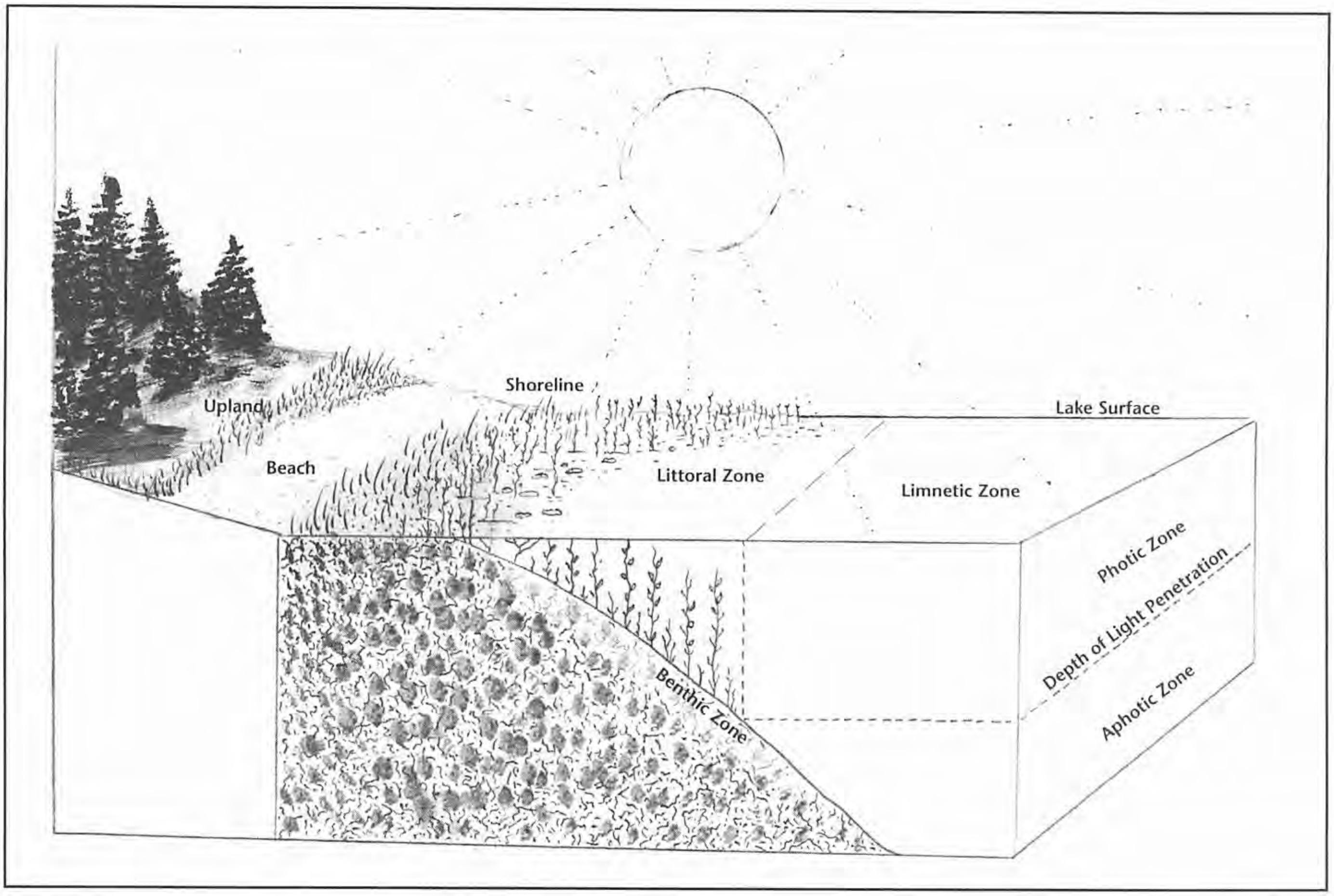


Figure 12 - Ecological regions of a lake.

- **Benthic or Profundal.** These terms refer to the entire lake bottom. This zone usually encompasses different bottom types, depending on depth, the rate and nature of sediment deposition, the composition of the original glacial or geological materials, and the physical features of a lake. Bottom type influences the number and kind of organisms (such as plants, insects, snails, and mussels) found there, and consequently the availability of food for fish. This region is also important for fish habitat because different fish species prefer or require different bottom types, especially for spawning.

- **Submersed structures.** This includes natural things such as woody debris (logs and sticks) and boulders; as well as brush piles, old tires, or other sunken objects placed by humans.

Lake Classification

A classification scheme with three basic categories has been developed for lakes. Eutrophic is the term given to fertile waters, with high levels of nutrients and resulting high productivity. Oligotrophic is used to describe waters of low productivity. Mesotrophic lakes are those of medium

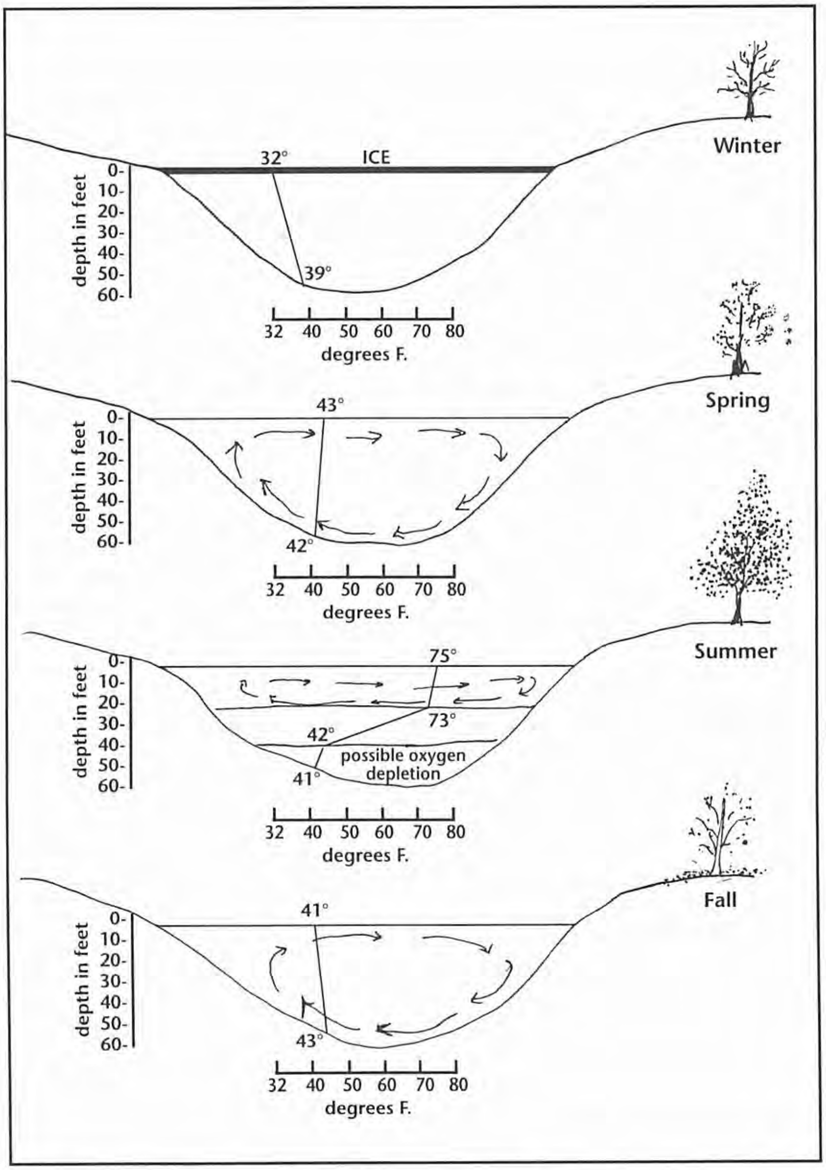


Figure 13 - Seasonal temperature and oxygen profiles of a lake.

Lake Stratification and its Effect on Fish

Lake water can become vertically layered in summer and winter, a condition called stratification (Figure 13). The different layers can develop very different water quality characteristics with great implications for fish life. This is due in part to several unique properties of water—it is most dense at 39 degrees Fahrenheit (F)., there is an upper limit to the amount of dissolved oxygen (D.O.) it can hold (termed saturation), and cold water can hold more dissolved oxygen than warm water.

In winter, a slight stratification develops with the coldest water in the lake near the surface (just under the ice) and the warmest water (up to, but no warmer than, 39 degrees F.) near the bottom. As spring progresses, the sun melts the ice and warms the surface layer, making all the water in the lake nearly the same temperature.

When wind blows across a lake's surface, subtle vertical and horizontal currents develop. The vertical currents which develop in spring are strong enough to mix the unstratified water in all the lakes of the Chain from surface to bottom—a phenomena called spring turnover. Through wave turbulence and the oxygen supplied by photosynthesis, the water becomes saturated with D.O. from top to bottom.

As spring turns to summer, the water continues to warm. If the lake is deep enough, a warm surface layer on top of a cold bottom layer (possibly as cold as 39 degrees F.) is established. The thickness of the warm surface layer is dependent on the strength of the vertical mixing currents—the bigger the waves, the stronger these mixing currents. In large lakes with large, powerful waves (like Torch, Elk, and Bellaire), the surface layer may be 50 feet or more thick. On smaller lakes (like those of the Upper Chain), it may only be 15 feet. Stratification does not develop if mixing occurs down to the lake's maximum depth (as is normally the case in Beals, Clam, and Skegemog Lakes). Besides wave size, the thickness of the surface layer also depends on how warm and/or windy it is during late spring or early summer.

When stratification is established, there is a narrow zone of rapid temperature change between the layers. The temperature

Lake Stratification and its Effect on Fish *-continued*

difference between the top and bottom layers may be as much as 40 degrees F. Because of the difference in water density at these two temperature extremes, mixing does not occur between the layers. Because light usually does not penetrate into the bottom layer, there is no oxygen replenishment from either photosynthesis or surface turbulence.

In lakes with moderate to high productivity, the use of D.O. by microbes can cause total depletion from the bottom waters. This is the situation in the holes deeper than 20 feet on most of the lakes of the Upper Chain. Without D.O., very little life (including fish) exists in the cold, dark bottom waters. However, in lakes with low productivity, the D.O. level in the bottom waters may actually be higher than the D.O. levels in the surface water (as is the case in Torch and Elk Lakes). Lake trout and whitefish need cold, well-oxygenated water, and this is one reason why the only lakes in the Chain with stable, naturally reproducing populations of these species are Torch and Elk. Lake Bellaire has some D.O. depletion at the bottom, but not throughout the bottom layer (See Figure 36 in Chapter Five).

In fall, the surface eventually cools to the point where wind-generated currents can again mix the water from top to bottom, and D.O. is recharged throughout all the lakes of the Chain. As winter sets in, the surfaces of the lakes become cold and freeze. The ice layer shuts off the supply of oxygen from turbulent mixing, but plants beneath the ice can still produce oxygen as long as sunlight can pass through the snow and ice. However, if the snow is deeper than about 12 inches, little light passes through and more oxygen is used by plants and microbes than is produced. In shallow, productive lakes, D.O. depletion can occur during winter. This is termed winterkill, because a large portion of the fish population can die. Winterkill lakes are typically not very good for sport fishing. No lakes of the Chain are known to develop winterkill conditions, but they would be most likely to develop on Beals and Scott's Lakes.

productivity. Eutrophication is the process of nutrient enrichment (or "aging"). It is a natural process usually taking thousands of years for significant change to occur. However, nutrient pollution can greatly accelerate the eutrophication process, resulting in excessive amounts of plant and algae growth, among other things.

The Stream Corridor

A stream is most influenced by its corridor (Figure 14). The stream corridor consists of the stream channel (the part which usually contains flowing water), floodplain (a highly variable area on one or two sides of the channel inundated by flood waters at periodic intervals ranging from frequent to rare), and the transitional fringe (the transition between the floodplain and the surrounding landscape, often a conifer swamp along Northern Michigan streams). All the components of the stream corridor function to moderate flow, store water, stabilize banks, shade waters, provide food and nutrients, filter pollutants, and provide habitat and travel corridors—to the benefit of fish and a variety of other wildlife.

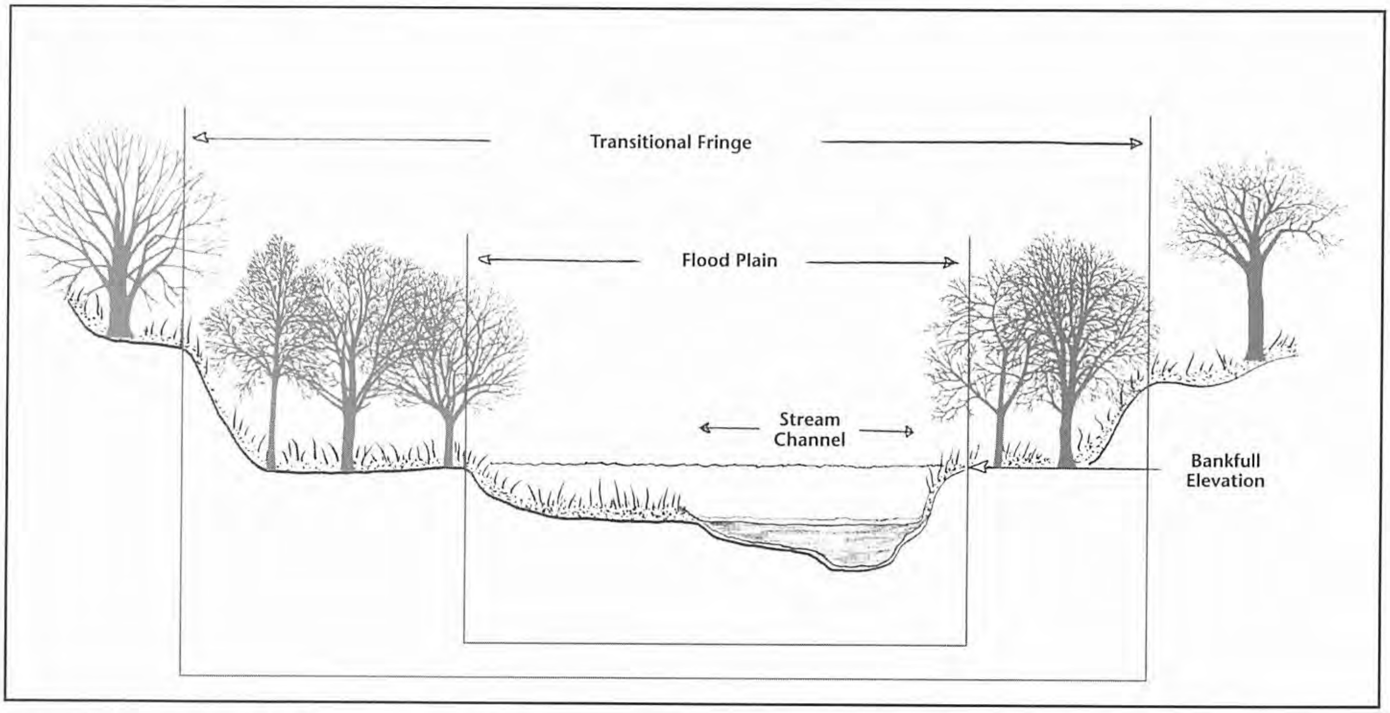


Figure 14 - Cross-sectional sketch of a stream corridor.

Stream Washload and Bedload

All streams carry a load of both dissolved and suspended materials which have been picked up along the course of the stream. The total sediment load being transported downstream at any given time is divided into two parts—washload and bedload.

Washload is composed of the finest particles which the turbulence of the current holds in suspension. Sometimes this is also referred to as suspended sediment or suspended solids. It is usually silt, clay, or light organic material. Bedload is the set of particles in constant contact with the stream bottom but moving along by rolling, sliding, tumbling, or slipping motions. The size of the particles that the stream can move as washload or bedload depends on the velocity and power of the flowing water.

The source of bedload material is usually the streambed itself. However, in Northern Michigan, because of the abundance of highly erodible sandy soils, soil erosion has created widespread sand bedload problems. This is because the streams in this region are of generally low velocity and power, and sand sediment which becomes deposited in the streams moves very slowly. If there is enough erosion and deposition, the sand bedload builds up excessively, covering gravel beds that fish use for spawning and food sources, and filling in deep holes that fish use for hiding and resting cover. If large enough, the sand deposits can even plug the channel, causing the stream to seek a new course with associated erosion and water quality problems.

Erosion and runoff which contributes sand and other sediments to streams is perhaps the most serious pollution threat facing streams in Northern Michigan. Improper and extensive logging practices around the turn of the century are thought to be responsible for much of the sand bedload, but road-stream crossings, agriculture, construction, and other activities continue to contribute sediment.

Sand traps have been constructed on some streams in an effort to reduce sand bedload and restore the stream to more natural conditions. Sand traps consist of excavating a deep basin in the streambed. A typical sand trap may be several hundred feet long and eight feet deep. The sand bedload which tumbles into the basin from upstream is trapped there, where it can be removed by periodic excavation and disposal in a remote upland area. Portable sand dredges are also being tried in some areas. Fortunately, the two largest trout streams in the ERCOL Watershed (the Cedar and Rapid) have high water velocity in most areas, and so sand bedload problems are relatively slight.

Velocity and Discharge

Streams can have wide fluctuations in flow from season to season. Most streams flow year-around (called perennial streams), but some only flow for limited times (called intermittent or ephemeral streams). Fish, of course, are generally confined to perennial streams.

Velocity is the distance a mass of water travels in a certain unit of time. It is usually measured in feet per second. Stream velocities can range from near motionless to 30 feet per second. The velocity of the water depends on volume, depth, and slope of the stream channel (called gradient); and the friction created by the bottom or in-stream objects, like logs and rocks.

Velocity is not evenly distributed throughout a stream channel. Highest velocities are usually found near the centers, or in the deepest parts, of the stream channel (Figure 15). It requires a lot of energy to stay stationary in flowing water, so fish usually spend most of their time near the stream bottom, sides, or around objects where the current is less strong.

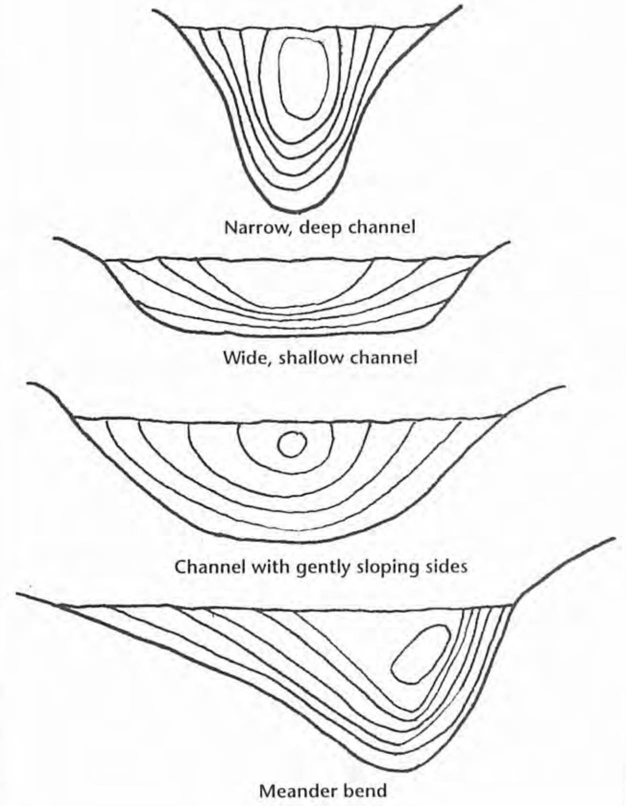


Figure 15 - Current velocity in channels with different shapes. Lines show areas of equal current velocity, with highest velocity near the center of the channel.

Discharge is the volume passing a given point in a certain amount of time. It is usually measured in cubic feet per second. Usually, there is a steady increase in discharge from headwaters to mouth (although some streams actually lose water to infiltration in some stream reaches). Stream discharge at any given point varies over time. Discharge and velocity are usually greatest in spring when melting snow, coupled with minimal evapotranspiration, produces the greatest runoff. Heavy rainstorms which exceed the soil's capacity for infiltration result in surface runoff, increasing discharge. Discharge is usually lowest in late summer.

A figure depicting a stream's discharge over time is called a hydrograph. As Figure 16 shows, extensive development in natural, forested watersheds can change a stream's discharge characteristics, which can in turn cause erosion, degrade aquatic habitats, and negatively impact fish populations.

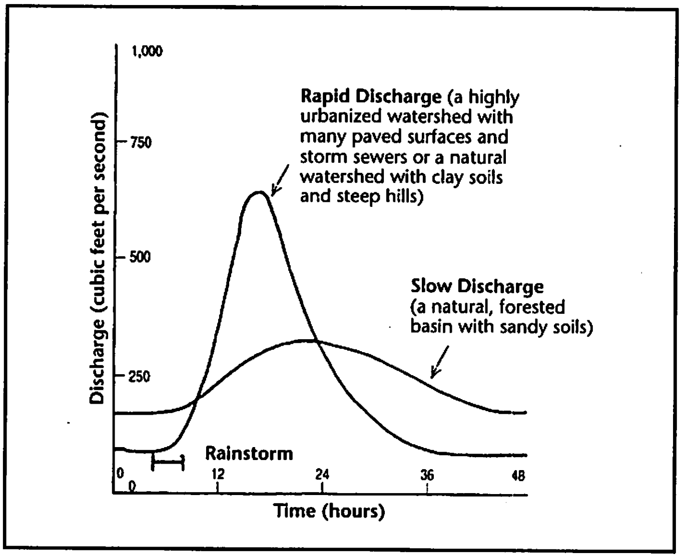


Figure 16 - Idealized hydrograph of two similarly sized streams in watersheds with fast and slow discharge following a rainstorm.

Stream Channel Features

Water flow within a channel is never perfectly uniform. Instead, the current swings from side to side exerting unequal erosive forces against the banks. As a result, stream channels which flow through glacial deposits are almost never straight for any great distance. Most streams in the ERCOL Watershed have a gently winding or sinuous channel. A strongly S-shaped curving pattern, called meandering, often develops in streams with low gradient in broad, flat valleys. There are not many meandering streams in the ERCOL watershed, but the Green River has a meander bend with a deep hole, locally known as "The Devil's Elbow."

Streams can have wide fluctuations in channel size and shape from place to place. Alternating series of shallow and deep areas, called riffles and pools (or holes) respectively, often form along a streambed. Although the reasons for their formation are not clear, riffles often form where the main current crosses from one side to another. Pools tend to be spaced at regular intervals—about five to seven stream widths apart (Figure 17).

Riffle and pool development occurs most commonly in cobble or gravel-bottomed streams with moderate gradient. Wide, flat-bottomed channels often form in sand-bottomed streams, while narrow and deep channels are characteristic of silt- or clay-bottomed streams. Stream channels can also be trapezoidal, semi-elliptical, triangular, etc. in cross section. In streams, fish are often found in pools because the current is slower, they provide concealment, and drifting insects or other food organisms are often abundant there.

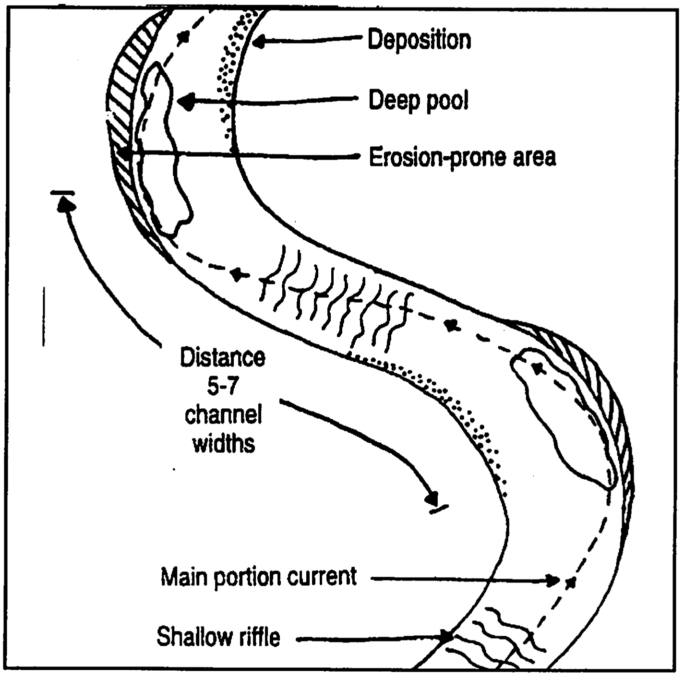


Figure 17 - Meandering and riffle-pool patterns in a stream.

As the current swings back and forth within the channel it flows against the bank in places, sometimes eroding the streambank and creating a cavern-like undercut bank. Undercut banks form important hiding and resting places for fish (Figure 18). Some erosion and the formation of undercut banks is natural on streambanks, but too much can cause bank instability and sedimentation. Woody vegetation helps keep streambanks stable. Oftentimes, undercut banks develop under tree roots.

Woody debris consists of trees that fall in the water from old age, wind-throw, beaver activity, or streambank erosion. Woody debris is a valuable and necessary component of the stream. It provides habitat for fish and invertebrates, stability to the streambed, and nutrients to the stream as it decays. Logs in a stream can last for centuries.

Stream bottoms can be composed of a variety of materials, including clay, silt, sand, gravel, cobbles, boulders, organic matter, and woody debris. Sand and silt are generally the least favorable bottom types for supporting aquatic organisms because they contain little oxygen below the top layer, and they are unstable and constantly in motion, burying organisms. Rock or gravel are generally the most productive because they provide stable substrates for bottom dwelling invertebrates and spawing sites for fish. Rock or gravel bottoms are most commonly found in steep gradient headwaters because the fast waters carry away fine particles. Sand, silt, and clay are more commonly found in low, flat areas near the stream mouth.

Bankside vegetation often grows out over the stream because there is more sunlight there. Terrestrial insects fall off the leaves, stems, and branches of this overhanging vegetation, providing food for fish. The vegetation creates shade, and can be an important factor in keeping a stream cool enough for trout. It can create a cavern-like shelter which fish like to hide beneath.

Stream Classification

As with lakes, stream productivity varies with nutrient level. Streams can also undergo eutrophication due to human nutrient pollution. However, they are less conducive to classification only on this feature because their productivity changes greatly over the course of their length.

A number of other classification schemes have been developed for streams. One of the most common is termed stream order, which is a grouping based on sequential tributary convergence. The uppermost parts of streams, those with no tributaries, are 1st order streams. A steam becomes 2nd order after the confluence of two 1st order streams, a 3rd order after the confluence of two 2nd order, and so on (Figure 19). Streams of similar order within a region are generally ecologically similar. Most 1st to 3rd order streams have a shaded canopy of trees wherever deforestation has not occurred. The Elk River is a 5th order stream. The Mississippi River, the largest river in North America and the world's seventh largest (based on discharge), is a 10th order stream.

Another classification is based on summer water temperature. Maximum and minimum stream temperatures can have a profound effect on species composition. As a result, streams, especially those in the Great Lakes region, are often classified as warm vs cold water or trout vs non-trout streams (because trout require cold water—if water gets too warm, trout die). In the ERCOL Watershed, streams discharging from lakes are considered warm water, while most other tributaries are cold water streams.

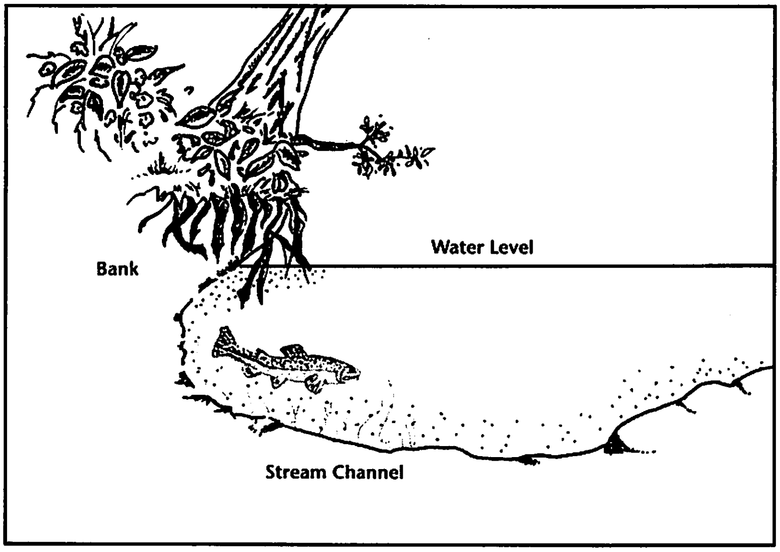


Figure 18 - An undercut bank.

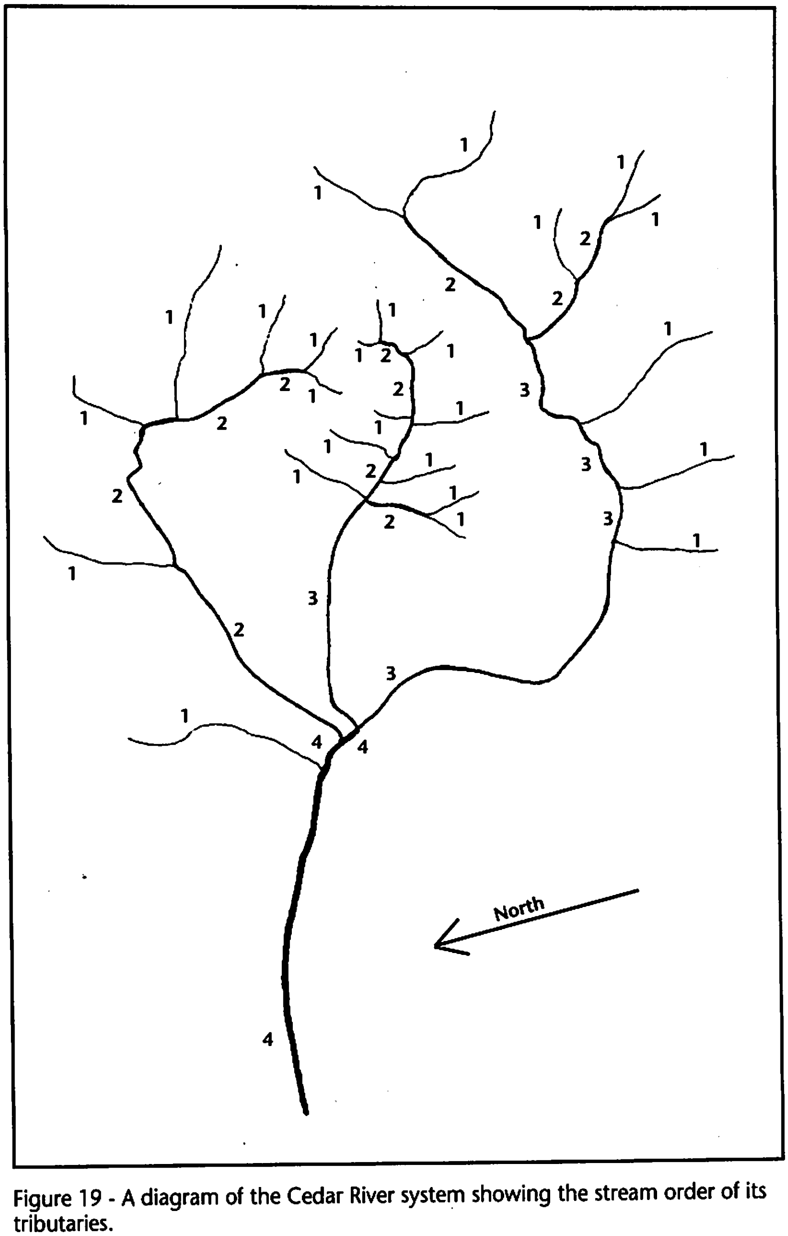


Figure 19 - A diagram of the Cedar River system showing the stream order of its tributaries.

—CHAPTER THREE—

The Ecology of Fish

A largemouth bass lies concealed beneath a canopy of pond lilies. Fish are the vertebrates most different from ourselves. They are the dominant vertebrate life form over nearly three quarters of the earth (the amount covered by water). This chapter will help the reader to understand how they live suspended and concealed from our view in the dense, fluid medium of water.

The origin and diversity of fish

The period of time between 345 and 425 million years ago (known as the Devonian and Silurian Periods to geologists) is sometimes called the age of fishes because that is when fish began to flourish in the Earth's waters. Since then, fish have become the largest group of vertebrates (animals with a spinal column).

More than half of all vertebrates are fish. There are currently about 22,000 recognized species of fish, and scientists think there may really be as many as 28,000. This large number makes sense because the world is about 70% water, and within this vast area are a great number of different habitats (places in the environment where fish and other organisms live) in which fish have become adapted to living. Fish are found from the deepest part of the oceans to an elevation of more than 15,000 feet (a vertical range of almost 10 miles), and from the poles to the equator. Fish range in length from less than one inch to more than 70 feet, and come in an incredible array of forms and colors. An understanding of how this diverse group of organisms functions and interacts with their environment is important for their protection and management.

The Classification of Fish

The identification, naming, and grouping of the millions of biological organisms on Earth has developed into a hierarchy with seven major classification categories:

1. kingdom
2. phylum
3. class
4. order
5. family
6. genus
7. species

Each category groups together organisms with similar characteristics. The broadest category is kingdom. There are five kingdoms, and fish belong to the one which groups together all animals. Figure 20 shows basic groups of organisms in the animal kingdom.

Fish are in the phylum with all other animals having spinal chords, and in the sub-phylum with all other animals with a spinal column (called vertebrates). Fish were formerly grouped together in one class called Pisces, from the Latin word meaning fish (Pisces is also the name of a northern constellation resembling a fish—one of the signs of the zodiac). Now, there are three classes of fish, depending on the type of skeleton or jaw structure. Most freshwater fish are in a class called Ostiecythes, meaning fishes with skeletons of bone. The species designation is the most narrow level of this classification scheme. A species is defined as an interbreeding population capable of producing fertile offspring. Basically, fish are aquatic vertebrates generally having gills in the adult stage and limbs in the form of fins.

(continued on next page)

External Fish Anatomy

Most fish have streamlined shapes to help them move easily through the water. However, many different shapes are found amongst the various species (Figure 21). A torpedo shape results in the least friction. Torpedo-shaped fish, like trout, are often found in streams with swift currents. Broad, flat shapes, like a bluegill's, result in better maneuverability. Fish with sleek shapes and fins set back near the tail, like northern pike, can accelerate very fast over a short distance when attacking prey. Forked tail fins are for speed and broad tail fins are for maneuverability. The longer the fish, the faster it can swim. A general rule is that a fish can swim seven miles per hour for each foot of length.

Fish have many combinations, shapes, and styles of fins. The dorsal (or back) fin helps maintain balance. Pectoral fins (the equivalent of human arms) and pelvic fins (corresponding to human legs) aid with fine tuning position and balance. Caudal (or tail) fins are the main propulsion unit. Figure 22 shows basic external anatomical features.

Most fish have scales, which are a tough form of skin cells forming a protective

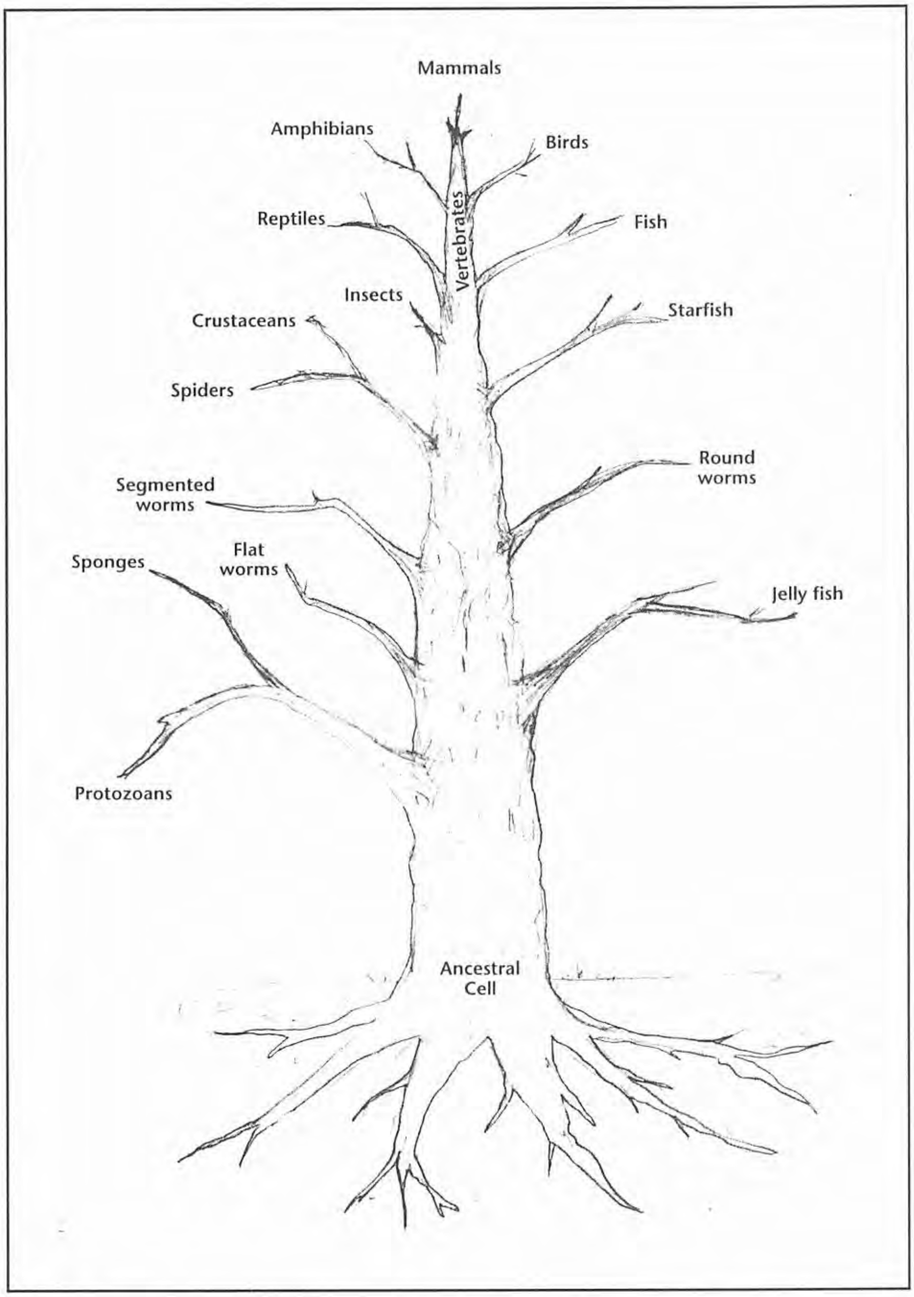


Figure 20 - Simplified evolutionary "tree" showing the categories within the animal kingdom.

The Classification of Fish
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The Classification of Fish
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The Classification of Fish
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The names used in this classification scheme are usually Latin, or Latinized. Each species is technically referred to using a two-word name consisting of the genus (very closely related organisms but not capable of producing viable offspring) and species categories, commonly known as the "scientific name." Scientific names are in Latin because it is a "dead language" and is no longer evolving and changing. In addition, Latin retains its integrity across many languages—the meanings don't change with translation. This universally used classification scheme allows scientists all over the world to understand and agree on the exact identification of a particular organism.

It is important to use scientific names for exact identification purposes because a particular species can be called by many different "common names" in different geographic areas. For instance, in different parts of North America, pickerel is the name used for what Michiganders commonly call both walleye and northern pike. It is also the name of another member of the pike family found in the southern U.S. Many of the scientific names for fishes (and other organisms) are actually more colorful and descriptively accurate than the common names. For example, the scientific name of the rock bass is *Ambloplites rupestris* which translates to dull colored fish living among rocks—in obvious reference to its appearance and habitat preference.

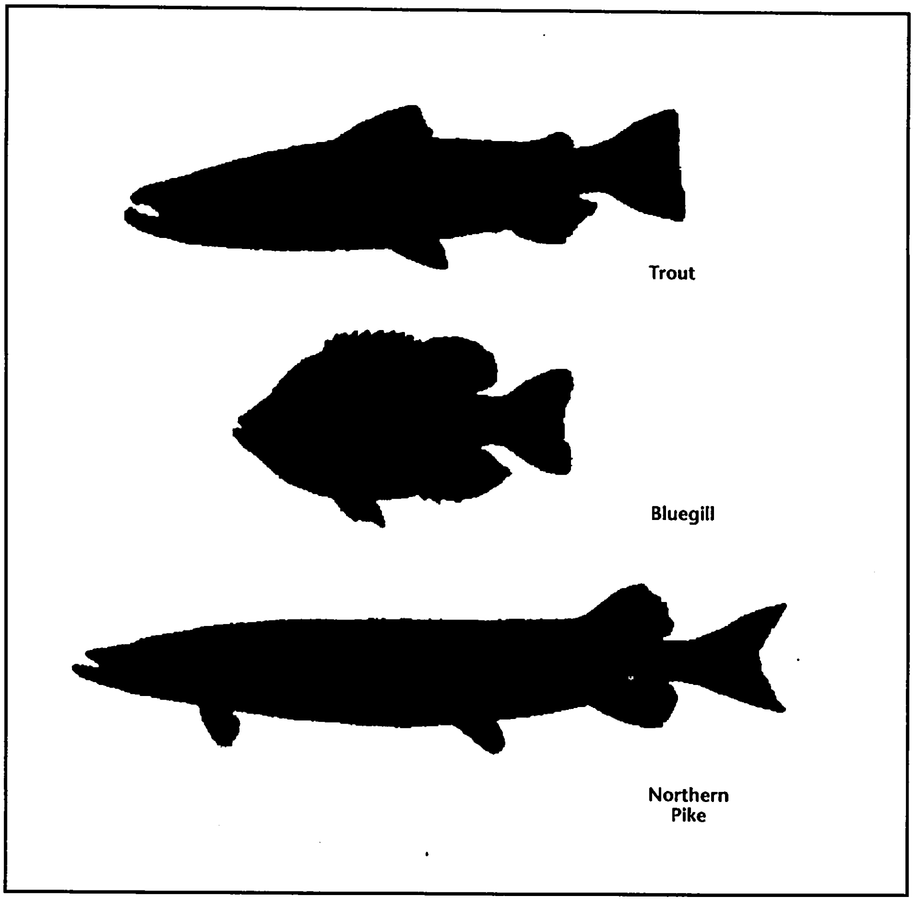


Figure 21 - Silhouettes of different fish shapes.

covering. A slimy secretion further coats a fish's body, protecting it against disease, fungus, and parasites; and reducing friction as the fish moves through the water.

Fish come in an incredible variety of colors and patterns. An individual fish's color can change, sometimes in very little time, in response to surroundings, behavior, or season. The color of a species may also vary between lakes or regions. For example, the smallmouth bass in Six Mile Lake have a dark greenish-bronze back with a dusky belly, while the same species in Torch Lake has a bright green upper half and a creamy-white belly. Colors and markings are useful for camouflage and recognition. Most fish are countershaded (dark on top and light beneath) which is an effective form of camouflage underwater.

Internal Fish Anatomy

Many of a fish's internal organs, such as stomach, intestines, liver, and kidney, are similar in appearance, location, and function to those of humans. However, fish have several internal organs which are unique.

Gills consist of fine, permeable, hollow filaments through which the blood flows. They create a large contact area with the water, allowing a fish to extract dissolved oxygen from water and expel carbon dioxide from its body. Water enters through the mouth when the fish moves, or through the opening and closing motions of the mouth, constantly forcing water back over the gills.

The gas, or swim, bladder aids fish in maintaining neutral buoyancy, and in avoiding sinking or floating. It is an air-tight sac which can be inflated or deflated to increase or decrease buoyancy. Freshwater fish have larger swim bladders than saltwater fish because fresh water is less buoyant.

Fish Senses

Fish have extremely good hearing. Studies have shown that some fish can hear the sound of a worm wiggling into the bottom sediment. A fish's ears are buried

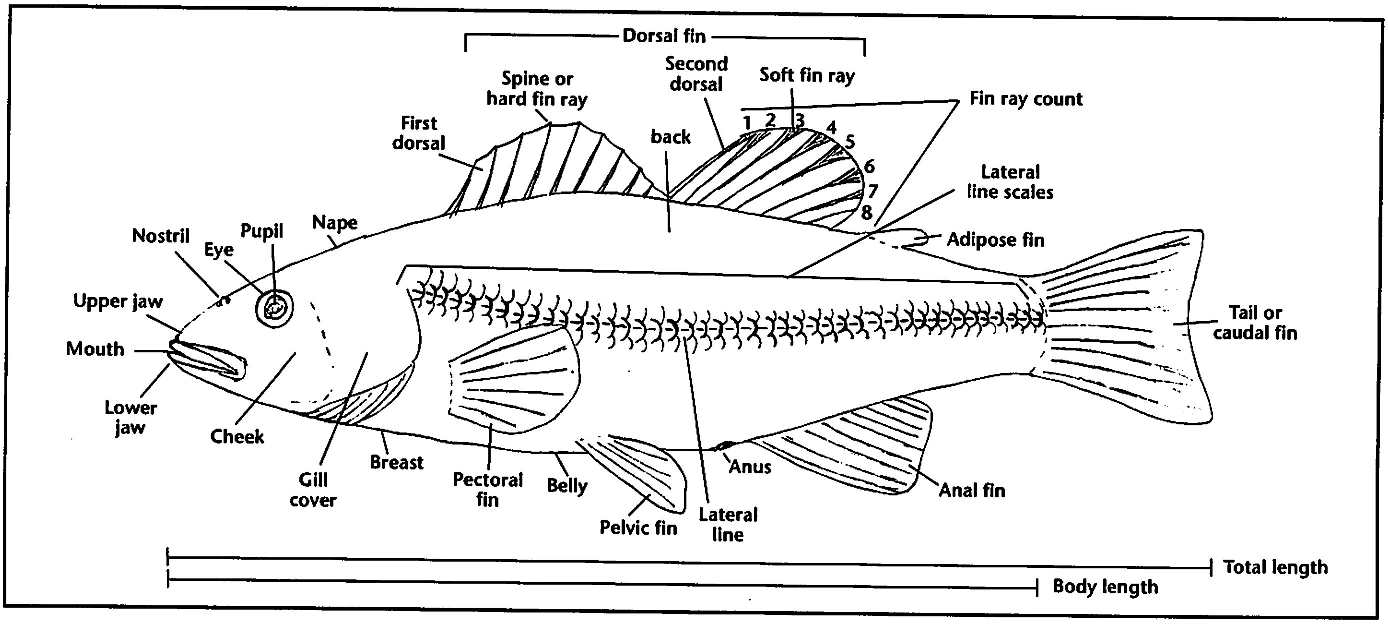


Figure 22 - External fish anatomy.

under its skin on either side of the head, and sound waves reach the ear by traveling through skin and bone. Some fish's ears are hooked to their swim bladder, which amplifies sound. In addition to ears, fish have a second, unique, sound detection system called a lateral line. It is incredibly accurate at detecting and locating the source of low frequency vibrations. Fish can use their lateral line to strike a black lure on a moonless night in turbid water. They can also plainly detect people talking in a boat above them.

Fish are nearsighted. Consequently, their eyes cannot focus on objects very far away. However, it really does not matter because water is not very transparent (5 to 50 feet in waters of the Chain). A fish's eye takes in a 180-degree field of view (like a "fish eye" camera lens), and each one sees independently of the other. Fish can perceive color, and they are very attuned to movement. Predatory fish have the best vision. Fish usually first detect and close in on their prey through smell or sound, but switch to visual mode just before striking.

Fish have nostrils, but they are not used for breathing. Behind the nostrils is a chamber lined with sensors capable of detecting minute odors. Fish use smell to detect food, perceive danger, and navigate. Species that feed at night probably have the best sense of smell. Fish have demonstrated an ability to perceive odors at concentrations as low as 80 parts per billion.

Feeding

Fish have differing food preferences. Some species, such as cisco, smelt, and many kinds of minnows, are planktivores, meaning they mainly feed on zooplankton. Many well-known game fish, like bass, trout, pike, and walleye, feed primarily on other fish. These are called piscivores (pronounced pie-sieve-ores). Others like sucker, bullhead, and sculpin, feed on a variety of organisms on the bottom, such as insects, algae, or detritus (non-living organic material). Most fish eat a variety of food items (called omnivores).

On average, a fish must consume food equaling one percent of its body weight per day to stay alive and active. A fish's food must first supply energy for body functions, feeding, spawning, migration, and defense. Any excess energy can then be utilized for growth. Fish generally do not feed when their stomach is full, and fish will generally not chase a food item very far because, energy-wise, it is not worth it.

Fish, and most other aquatic organisms, are cold-blooded, meaning their bodies are the same temperature as the water. As a result, water temperature governs many biochemical and physiological processes, including feeding. The colder the water, the less food a fish requires and the less it feeds. Digestive processes and other body functions slow in cold water. It takes a fish about 15 hours to digest and assimilate food at 72° F., and about four days in 35° F water.

Different fish prefer different water temperatures, and can tolerate different temperature ranges (Figure 23). In Michigan, they are generally classified as coldwater (e.g., trout), coolwater (e.g., walleye), or warmwater (e.g., bluegill) species.

Age and Growth of Fish

Fish continue growing in length and weight throughout their life. Growth rate largely depends on food supply. If food supply is low, fish growth may be almost nonexistent. This is why some fish of the same species grow faster than others. However, even fish which have been starving and growing slowly have the ability to resume normal or even rapid growth, with no apparent long-term ill effects, if food becomes abundant. Figure 24 shows average age-growth relationships of various species of fish.

Food availability is actually a function of the quantity of food coupled with the number of fish or other organisms competing for the same food source. Other factors affecting the growth rate of fish include difficulty of food capture; water temperature; sexual differences (males or females grow

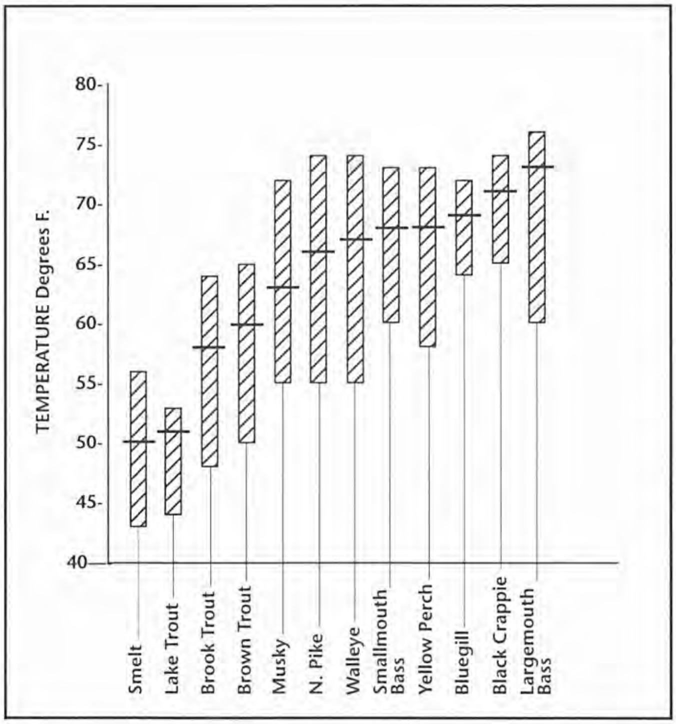


Figure 23 - Graph of the preferred temperature ranges of selected fish species, with peak feeding temperature indicated by a bar.

SPECIES	YEARS OF AGE 1	2	3	4	5	6	7	8	9	10	11
Brook Trout (streams)	2.7	5.7	8.2	10.4	13.9	16.7					
Brown Trout (streams)	3.0	6.4	9.0	11.5	15.1	18.8	21.3	23.9			
Yellow Perch	3.1	4.6	6.1	7.0	8.0	9.0	9.9	10.7	11.3	11.8	12.3
Bluegill	2.3	3.4	4.4	5.5	6.4	7.0	7.5	7.9	8.6	8.8	9.1
Pumpkinseed	2.8	3.3	4.4	5.2	5.9	6.4	6.9	7.3	7.8		
Rock Bass	1.5	3.1	4.5	5.6	6.5	7.4	8.2	8.9	9.6	9.9	10.1
Largemouth Bass	3.6	6.1	8.6	10.5	12.2	13.6	15.1	16.7	17.7	18.8	19.8
Smallmouth Bass	3.4	6.1	9.2	11.3	13.3	14.9	15.7	16.8	17.5	18.5	19.2
Walleye	7.1	9.5	13.3	15.2	17.2	18.6	19.2	19.6	21.6	21.4	25.2
Muskellunge	6.8	15.7	19.9	25.1	31.9	34.7	36.8	39.2	41.1	45.3	48.7
Northern Pike	10.2	15.6	19.4	22.2	24.6	26.5	28.9	32.7	33.4	38.7	39.6
White Sucker	3.5	8.6	12.0	14.3	16.3	16.9	18.1				

Figure 24 - Table of average age-growth (in inches) relationships in Michigan for selected fish species (MDNR, 1985).

biggest in some species); age (young and old fish grow slowest); and stressful conditions (such as low oxygen, toxic substances, or diseases).

A strong correlation exists between the length and weight of each species of fish. Another term for this relationship is condition factor. Condition factor can be used as an index of well being for fish. When fish are heavier than normal for a certain length, they have a higher condition factor and are generally considered healthier. Condition factor may also be influenced by sex, age, season, or stomach fullness.

In addition to abundant food, high condition factors may indicate over fishing or poor reproductive success, because more food is available to fewer individuals. Populations which have a low condition factor may indicate overcrowding, starvation, or disease. Charts have been developed showing the average length-weight relationship for common game fish (Figures 25 and 26). They are valuable for catch and release fishing because anglers can accurately estimate a fish's weight without the stress of weighing it.

The maximum age to which fish live is highly variable, both between species and even within populations of the same species. The largest species tend to be the most long-lived.

Fish Reproduction

Reproduction in most fish species (called spawning) begins when males and females come into close proximity and release eggs and sperm simultaneously into the water, resulting in egg fertilization. After fertilization, a fish embryo begins developing inside the egg. The egg hatches into a larvae (an early life stage which differs greatly in appearance from the adult). Initially, the larvae continue to rely on the yolk (which remains attached to their bodies) for food. Larvae at this stage are also known as a yolk-sac fry or alevin. When the yolk sac is depleted, larvae then begin to swim actively and search for food. This larval stage is also known as feeding fry or swim-up fry (Figure 27).

Most species randomly deposit their eggs in the spawning area and provide little or no protection or care to the young. However, some species build elaborate nests and actively guard the nest until the young can swim well. In general, fish produce large numbers of eggs per female—sometimes hundreds of thousands! This is to compensate for high mortality rates during the early life stages–relatively few larvae survive their first year.

In most species, it is difficult to determine the sex of a fish based on external characteristics. Sometimes the fins have different size and shape. Some fish develop distinctive gender-specific external characteristics during spawning, such as a pot belly (from eggs), knobs or bumps in the head region (known as tubercules), bright colors, hooked jaw, or specialized behavior.

Different species spawn at different times of the year. The length of the spawning period may also vary considerably. Water temperature and the amount of light are the two most important factors that trigger spawning.

The length of time between spawning and hatching is temperature-dependent. Hatching and larval development tends to be most rapid in the warmest water. As with longevity, different species reach sexual maturity at different ages. Short-lived species mature faster than long-lived ones. Not all fish within the same population reach maturity at the same age. Once mature, fish may not spawn every year. Old fish usually experience a gradual loss of reproductive capacity.

Many fish require certain types of habitats for spawning. For example, most members of the trout family spawn only in pure gravel in streams, and pike prefer shallow weedy areas in lakes or flooded areas along streams. Tributary streams and shoreline wetlands are often important spawning and nursery areas. If preferred spawning habitats are absent or degraded, reproductive success of fish may be poor or absent.

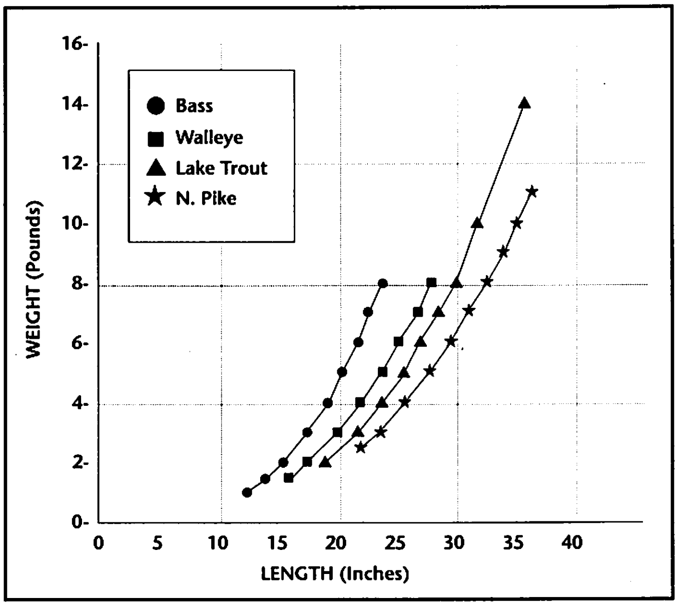
The number of eggs which survive the first year to become part of the population is termed recruitment. Recruitment success can vary widely from year to year, as well as between water bodies. When there are relatively large numbers of new recruits in a single year, it is termed a strong year class. Environmental and biological factors primarily influence the success of egg and larval survival and determine year class strength.

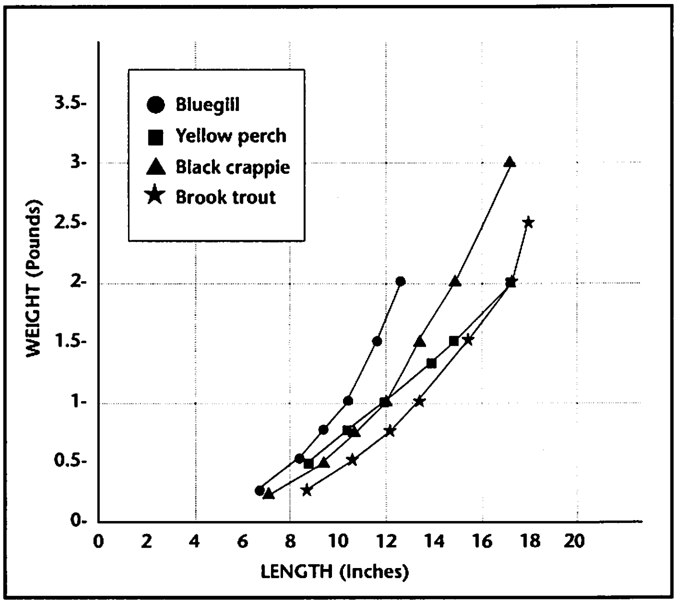
The Importance of Genetics

As explained earlier, physical features of fish are highly variable in response to environmental factors. Additionally, fish (like all other sexually reproducing organisms) have some degree of variability that results from genetic differences among individuals.

Fish species occur over wide geographic regions, and there is relatively little, if any, interbreeding between fish in waters separated by large distances. Inherited genetic differences can result in development of subspecies, strains, or stocks that are genetically unique, and are best suited to survive or reproduce within a certain region, watershed, or even a particular lake or stream. This genetic "fingerprint" can actually be identified and distinguished using sophisticated testing methods (similar to the DNA testing almost everyone has heard of associated with criminal trials). Because of these local genetic adaptations, transplants of a population from one region to another in which they may be genetically poorly suited often fail, or worse, genetically weaken the native population.

Fishing, which tends to remove the largest fish from a population, can theoretically affect the genetic makeup of





Figures 25 and 26 - Graphs showing typical length-weight relationships of selected fish species.

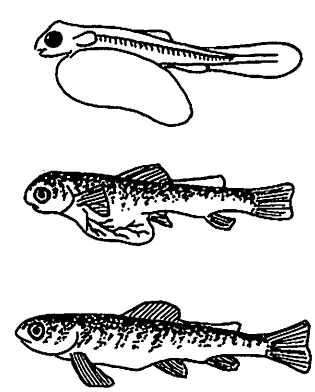


Figure from *Freshwater Fish Pond Culture and Management*, published by VITA, 1976

Figure 27 - A larval rainbow trout undergoing transition from an aelvin to a swim-up fry.

the population in favor of slower-growing individuals, or by reducing the gene pool in smaller water bodies (although this has not been shown to be a problem in the studies conducted to date).

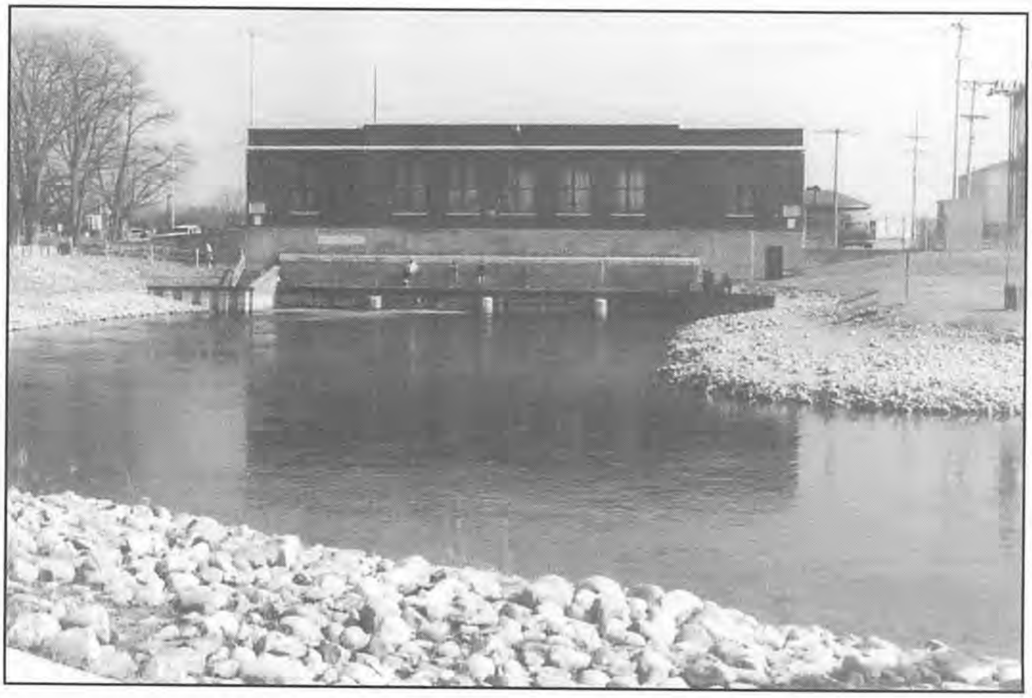


Figure 28 - The dam and powerhouse on the Elk River, which now blocks the movement of fish between the Chain of Lakes and the Great Lakes.

Fish Mortality

Predation, parasitism, disease, starvation, fishing, and poor water quality (either naturally occurring from things such as high temperature, low oxygen, or rapid temperature change; or due to pollution) all contribute to fish mortality. Mortality is typically highest during the larval stage because of susceptibility to predation and water quality conditions. Spawning is stressful, and can make fish more susceptible to disease and infections. Males usually die at an earlier age than females. Fishing mortality mostly affects older, larger fish (although poor catch and release practices can also cause significant mortality among undersize fish). Many mortality factors depend on a species' population density. For instance, when populations are high, there may be more fishing activity or chances for diseases to spread.

Fish Populations and Communities

A fish population is defined as all the fish of the same species that occur within a given lake, stream, or watershed. The fish community is the assemblage of all of the populations. Numerous factors determine population and community composition.

The opportunity for natural migration and colonization, as well as introductions by humans are two major factors determining which species will occur in a given water body. Natural patterns of fish distribution tend to follow major watershed systems. For instance, fish communities are notably different between waters of the Great Lakes and Mississippi River watersheds. Waters that are connected tend to have the most similar fish communities. In general, waters that are geographically isolated tend to support fewer species than more broadly-connected systems. The 67 species found in the Chain of Lakes system is a relatively high number, and is a reflection of the system's formerly close connection with Lake Michigan (before the Elk Rapids Dam was built, Figure 28).

Population age structure refers to the number of fish in each age or year class. Determining age structure can provide important information on population status and trends. When birth and mortality rates are constant, the numbers of fish in each year class will decline steadily with increasing fish age. Large year classes can indicate good reproductive success or low mortality. Missing year classes usually indicate a year of complete reproductive failure. Occasional missing year classes are a natural occurence due to poor weather conditions during spawning or other factors. However, successive missing year classes may indicate environmental or habitat problems. Information about reproduction, growth, and mortality is necessary to understand the population dynamics of a species.

Habitat characteristics and species interactions also determine the community structure and species abundance. Fish species with similar habitat requirements tend to co-occur, while species that prefer distinctly different habitat types often do not co-occur, except in large water bodies with diverse habitats. As a result, fish communities can be classified into general categories. Often, they are named for major sport species such as bass/panfish, lake trout/ whitefish, or pike/perch/walleye. Predation and competition can also affect community composition.

An understanding of fish habitat requirements is important for determining what factors may be limiting fish population success or productivity. The same understanding is important to help design and evaluate fish habitat protection and management projects. The abundance of every species is directly affected by the abundance of species which compete with, prey upon, or are prey for it; and individual species cannot be managed without considering the broader biological community within which they coexist.

—CHAPTER FOUR—

Fish of the Elk River Chain of Lakes Watershed

Photo courtesy *Antrim County News*

Sturgeon, like this monster taken in the Torch River (not Torch Lake, as the caption indicates) in 1925, may have been common in the past. Imagine peering through the clear waters of the River and seeing fish weighing 100 pounds or more! Although anglers occasionally still report hooking something too big to lift off the bottom, at best only a remnant population of sturgeon remains. About 64 very interesting and important species—from tiny brook stickleback to enormous Great Lakes musky—still thrive today in the rich, diverse habitat provided throughout the Chain of Lakes Watershed.

Species found in the Elk River Chain of Lakes

Sixty-seven species representing nineteen families[1] are known to occur, have occurred within historic times, or are within the known range for that species in the Elk River Chain of Lakes Watershed (see accompanying table). This compares with 152 species of fish representing 29 families known to occur in Michigan (as of December, 1997), and 145 species present in the Lake Michigan Watershed. However, with the rapid, unintentional introduction of exotic species, the number of species in Michigan and the Great Lakes Watershed is constantly increasing.

Of the species listed for the Chain of Lakes Watershed, one is extinct in Michigan (arctic grayling), two are listed as threatened within the State (lake sturgeon and cisco), and five are introduced (rainbow smelt, brown and rainbow trout, and Atlantic and kokanee salmon). A brief description of each of these species is presented in this chapter.

[1]See Chapter Three for more information about fish classification

Fish Species in the Elk River Watershed[2]

Lamprey Family *Petromyzontidae*
Northern book lamprey *Ichthyomyzon fossor*
American brook lamprey *Lampetra appendix*

Sturgeon Family *Acipenseridae*
Lake sturgeon *Ascipenser fulvescens*

Gar Family *Lepisosteidae*
Longnose gar *Lepisosteus osseus*

Bowfin Family *Amiidae*
Bowfin *Amia calva*

Minnow Family *Cyprinidae*
Lake chub *Couesius plumbeus*
Brassy minnow *Hybognathus hankinsoni*
Common shiner *Luxilus cornutus*
Blackchin shimer *Notropis heterodon*
Blacknose shiner *Notropis heterolepis*
Spottail shiner *Notropis hudsonius*
Sand shiner *Notropis stramineus*
Fathead minnow *Pimephales promelas*
Creek chub *Semotilus atromaculatus*
Northern redbelly dace *Phoxinus eos*
Pearl dace *Margariscus margarita*
Golden shiner *Notemigonus crysoleucas*
Emerald shiner *Notropis atherinoides*
Rosyface shiner *Notropis rubellus*
Mimic shiner *Notropis volucellus*
Finescale dace *Phoxinus neogaeus*
Bluntnose minnow *Pimephales notatus*
Blacknose dace *Rhinichthys atratulus*
Longnose dace *Rhinichthys cataractae*

Sucker Family *Catostomidae*
Longnose sucker *Catostomus catostomus*
White sucker *Catostomus commersoni*
Shorthead redhorse *Moxostoma valenciennesi*

Catfish Family *Ictaluridae*
Black bullhead *Amieurus melas*
Yellow bullhead *Amieurus natalis*
Brown bullhead *Amieurus nebulosus*
Channel catfish *Ictalurus punctatus*

Pike Family *Esocidae*
Northern pike *Esox lucius*
Great Lakes muskellunge *Esox masquinongy masquinongy*

Mudminnow Family *Umbridae*
Central mudminnow *Umbra limi*

Smelt Family *Osmeridae*
Rainbow smelt *Osmerus mordax*

Trout Family *Salmonidae*
Lake herring or cisco *Coregonus artedi*
Lake whitefish *Coregonus clupeaformis*
Rainbow trout *Onchorynchus mykiss*
Kokanee salmon *Onchorynchus nerka*
Atlantic salmon *Salmo salar*
Brown trout *Salmo trutta*
Brook trout *Salvelinus fontinalis*
Lake trout *Salvelinus namaycush*
Arctic grayling *Thymallus arcticus*

Troutperch Family *Percopsidae*
Troutperch *Percopsis omiscomaycus*

Freshwater Cod Family *Lotidae*
Burbot *Lota lota*

Killifish Family *Fundulidae*
Banded killifish *Fundulus diaphanus*

Silverside Family *Atherinidae*
Brook silversides *Labidesthes sicculus*

Stickleback Family *Gasterosteidae*
Brook stickleback *Culaea inconstans*
Ninespine stickleback *Pungitius pungitius*

Sculpin Family *Cottidae*
Mottled sculpin *Cottus bairdi*
Slimy sculpin *Cottus cognatus*
Deepwater sculpin *Myoxocephalus thompsoni*

Sunfish Family *Centrarchidae*
Rock bass *Ambloplites rupestris*
Green sunfish *Lepomis cyanellus*
Pumpkinseed sunfish *Lepomis gibbosus*
Bluegill *Lepomis macrochirus*
Longear sunfish *Lepomis megalotis*
Smallmouth bass *Miocropterus dolomieu*
Largemouth bass *Micropterus salmoides*
Black crappie *Pomoxis nigromaculatus*

Perch Family *Percidae*
Iowa darter *Etheostoma exile*
Johnny darter *Etheostoma nigrum*
Logperch *Percina caprodes*
Blackside darter *Percina maculata*
Yellow perch *Perca flavescens*
Walleye *Stizostedion vitreum*

[2]The list includes species currently known to be present, as well as species formerly known to be present but now extirpated, and species whose known range surrounds the ERCOL Watershed, but for which there have been no recorded collections there.

Fish Watching for the Non-Angler

Catching fish is one way to see them up close and personal. Because anglers spend a lot of time on the water, they also often get good looks at fish swimming or surfacing nearby. If you are not an angler, it may seem like your chances for seeing fish are limited because their secluded underwater habitats are so inaccessible, but this is not necessarily the case.

There is a good chance that fish can be seen anytime simply by looking down through calm, clear, shallow waters. However, due to the refractive (light-bending) properties of water and the visual capability of fish, if you can see them, they can usually also see you. As a result, often the only view of wild fish is a blurred glimpse as they dart quickly for cover. The chances of getting close enough to wild fish to identify them or observe their natural behavior can be improved by the following:

- Avoiding quick movements,
- Approaching softly and silently (a fish can easily sense vibrations from heavy foot-falls or loud voices),
- Positioning yourself so that the sun causes the least glare and does not cast your shadow over the fish,
- Timing fishwatching when the sun is high in the sky and underwater light penetration is greatest (although this is not necessarily when fish activity is greatest),
- Approaching from downstream (stream fish normally face into the current),
- Looking in likely habitats, such as along logs, weed beds, drop-offs, and undercut banks, and,
- Remaining very still or concealed if possible, once a fish is spotted.

Fish can be observed from both land- and water-based vantage points. Land-based places in the Chain of Lakes which could result in good success include:

- The walkway on the downstream side of the Elk Rapids Dam,
- The clear waters of the upper Torch River from either the bridge or the banks,
- Boardwalks along, and bridges over, Finch Creek at the Grass River Natural Area,
- Paths along, and bridges over, the Rapid River on the Seven Bridges property,
- The boardwalk on the north side of Clam River near its mouth.

On the water, try drifting or paddling slowly in a small rowboat, kayak, or canoe. One of the most basic aids to fish watching is the use of polarized sunglasses. The polarized lenses cut glare associated with reflection of light off the water surface (even on a cloudy day) and allow much better visibility of underwater objects.

In winter, cold water and diminished light result in low plankton numbers and very clear conditions in lakes. As ice anglers know, peering through a hole in an ice shanty provides an illuminating window on the world below. Sometimes, it is amazing how many fish can be seen (and how few bite at the bait). Although bait helps attract fish to the area of the hole, non-anglers might see fish or other interesting underwater sights simply by lying on the ice and covering the hole and head with a blanket (to cut interference from background light). Times when the ice is between three and six inches thick are best, because the ice is safe, but not yet too thick to diminish light penetration or prohibit easy hole-making.

Fish seem to be easier to approach in the dark, and some species are more active at night. Powerful spotlights mounted on a boat, or even hand-held flashlights carried along small streams or lakeshores, can illuminate fish at night. Early spring just after ice-out is usually a time of very clear water, and the fish are also often relatively lethargic and in shallow water. With use of a light at night, the water needs to be almost perfectly still, otherwise reflections and shadows make observations almost impossible.

Underwater viewing scopes can also increase underwater visibility by cutting the interference of background light and stilling the water surface. They typically consist of a tube several feet long with handles, colored black inside, contoured to fit the face on one end, with a glass plate on the bottom end. In effect, they are like looking through an elongated, hand-held diving mask while still on the surface, or peering through a hole in the ice (Figure 29). Viewing scopes can be constructed using plastic pipe and plexiglass, or purchased from several commercial sources including:

- SeaView™ by Basic Designs, Inc., 5815 Bennett Valley Rd, Santa Rosa, CA 95404, (707) 575-1220
- Aqua Scope™ by Lawrence Enterprises, P.O. Box 344, Seal Harbor, ME 04675, (207) 276-5746

To get as close as possible to the fish, try entering their world using SCUBA or snorkeling gear. SCUBA gear is quite expensive and requires training and certification. However, it allows deep, extended diving. With practice, snorkelers can safely dive to depths of ten or more feet. Even by just floating along on the surface, snorkelers may see much of the life present in the sunlit shallows of a lake or stream. Snorkeling in a trout stream is particularly cool, both in terms of water temperature (consider a wetsuit) and potential observations (because the water is usually very clear and everything within the stream is potentially within view). When underwater, fish do not seem to be so alarmed by the presence of people. Once fish are spotted, lie still or swim slowly to avoid disturbing them. Sometimes, fish will even approach a diver.

Many freshwater fish do well in aquariums, if properly cared for, and make interesting pets. Although live game fish as defined by Michigan's fishing regulations (17 species including trout, bass, pike, musky, walleye, sturgeon, crappie, bluegill, pumpkinseed sunfish, and yellow perch) cannot be kept without a special permit, other species such as darters, sculpins, sticklebacks, and minnows can be. These species can be collected with seines, hand nets, or hook and line in accordance with Michigan fishing regulations (remember to buy a fishing license). One advantage to having local native fish as aquarium pets is that they can be released back to the spot they were collected, if and when their novelty wears off. For complete information about Michigan's fishing regulations, check out the link to DNR laws, rules, and regs from the Law Enforcement Division's homepage on the Michigan Department of Natural Resource's website (www.dnr.state.mi.us).

Identification of Fish

Figure 29 - An underwater viewing scope can help reveal the hidden world beneath the boat.

Most people can probably tell a bass from a trout. Experienced anglers and naturalists often can easily identify different species of sport fish at a glance. However, exact identification—especially for non-sport or uncommon species—can be much more puzzling. For these species the use of a key requiring close inspection of the fish's structures and features is usually needed.

External features commonly used for identification include comparative body measurements such as length and depth; the number of fin rays, and their type (both soft rays and spines) and features; presence or absence of scales, or scale counts; position and characteristics of teeth, fins, and gill rakers (special appendages attached to the gills); and colors, patterns, and markings (Figure 22). Although some species are distinctively colored, fish colors are highly variable and are not generally good identification features. Most species can be identified based solely on external features, but for some, examination of internal features, such as parts of the digestive tract, is needed. For small species or specimens, a magnifying glass, forceps, scissors, or dissecting needles may be needed for identification.

Learning to identify fish can be fun and interesting. In fact, it is a necessity for anglers to comply with regulations. Misidentification can lead to violations, fines, and negatively impact fish populations. However, this guidebook is not intended to serve as a detailed guide for exact identification of all the fish species in the Chain. The following references were consulted in the development of this chapter, and they are recommended sources of more detailed identification and natural history information:

- *Fishes of Wisconsin* by George C. Becker
- *How to Identify the Freshwater Fishes* by Samuel Eddy
- *Fishes of Canada* by W.B Scott and E.J.Crossman
- *Fishes of the Great Lakes* by Carl Hubbs and Karl Lagler
- *Thompson's Guide To Freshwater Fishes* by Peter Thompson

Lamprey Family

Lampreys are a primitive type of fish, with the oldest fossils dating back about 300 million years. There are 30 species in eight genera worldwide. In North America, there are 17 species in three genera, 13 of which are strictly freshwater. In the Chain of Lakes there are two species in two genera. Fortunately, the exotic, parasitic sea lamprey, which has devastated Great Lakes fisheries, is not found in the Chain of Lakes Watershed.

Lampreys are all scaleless, round in cross-section and eel-like, with skeletons of cartilage rather than bone. They have only two fins (a long dorsal fin and tail fin, but no paired fins), a single nostril between the eyes, and seven sets of pouch-like gill openings. Lampreys have distinct larval and adult stages. They live most of their lives in the larval stage (which is known as an ammocete) in burrows in the soft bottoms of streams or lakes. Ammocetes are blind and toothless. When they transform into adults, they develop circular, well-toothed, sucking mouths. Many species are parasites, attaching to larger fish, rasping a hole, and feeding on blood and tissues.

Northern brook lamprey *Ichthyomyzon fossor*
(the scientific names mean sucker of fish and a digger)

The adult northern brook lamprey is grey to brown on the back and sides, pale grey or silvery white on the belly, turning blue-black following spawning. It grows to be four to 6.5 inches long. Adults are actually a little smaller than the maximum size of the larvae.

The northern brook lamprey is found in the Mississippi and Great Lakes Watersheds. It lives secretively in all kinds of rivers and streams, but is most common in pools with sand-silt bottoms in medium-sized, non-trout streams (averaging 50 feet wide and two feet deep). It is generally found in larger streams than the similar American brook lamprey, and the two species are not usually found together in abundance.

Spawning occurs during May and June when the water temperature reaches 65 to 68° F. Nests are built in gravelly areas among stones. Multiple individuals can be involved in nest building. After the nest is built, the female attaches to a stone with her sucking mouth, and the male attaches nearby to the stone or to the female's head. Their bodies vibrate and the eggs and sperm are simultaneously released. Females can lay more than a thousand eggs.

The eggs hatch in about 12 days. The larval young become free-swimming for several days before forming a U-shaped burrow in the sediment. Northern brook lamprey live in the larval stage for three to six years before transforming into adults. Microscopic algae are the primary food of the larvae. Transformation to an adult occurs during winter, at which time they develop eyes, a sucking disc with teeth, and become free-swimming adults.

The adults live only long enough to spawn, and usually die within a few days of spawning. The adult is nonparasitic. In fact, the adults do not feed at all. They are occasionally eaten by other fish, and are reportedly sometimes used as bait in Canada.

American brook lamprey *Lampetra appendix*

(the scientific genus name means sucker of stone)

The adult American brook lamprey is dark brown on the back and lighter brown on the underside, and has yellowish fins and a dark blotch at the end of the tail. It grows to be 5.5 to 7.5 inches long.

The American Brook lamprey is found in East-Central North America, from Connecticut to Maryland on the east coast, throughout the Great Lakes Watershed, and in the Mississippi Watershed south to Tennessee and Missouri. However, it is uncommon in the Lake Michigan and Lake Superior Watersheds. It prefers small, cool streams, often in association with trout and sculpin.

Spawning occurs during April and May. It takes place when the water temperature reaches about 63° F. Males construct an oval depression (about five by seven inches) for a nest. Larger stones are removed from the nest by sucking onto them and wrestling them out. Multiple individuals can be involved in nest building. After the nest is built, the females attach to a stone in or next to the nest, and the male attaches to the female's head. Their bodies entwine and vibrate, and the eggs and sperm are simultaneously released.

After hatching, the larvae are carried downstream to quieter water where they burrow into sand and silt. The larval stage is thought to last about five years. The larvae eat microscopic algae using a sieve-like structure. The transformation to an adult occurs during late summer, at which time they develop eyes, a membrane covering the head develops into a sucking disc, and they become free-swimming. They live as adults throughout the fall and winter. Although adults do not normally feed, there is evidence that they can be parasitic. They are utilized as food by other fish during their adult stage.

Sturgeon Family

The lake sturgeon is a member of an ancient group of fish which developed about 100 million years ago. Worldwide, there are 23 species in four genera. There are seven species in four genera in North America. Four of these live in the ocean (but spawn in freshwater rivers). Two species in two genera are found in Michigan. Lake sturgeon are the only species in the Chain of Lakes area. All types of sturgeon are dwindling worldwide because of dams, pollution, and over harvesting.

All members of the sturgeon family have a long, hard snout; a mouth on the underside of the head which can be protruded; four barbels; and prominent bony plates in five rows (one on the back, and two on each side); and a tail with the upper lobe larger than the lower lobe.

Lake sturgeon *Ascipenser fulvescens*

(the scientific names mean sturgeon and dull, yellow color)

The lake sturgeon is found in large rivers and lakes in the St. Lawrence River, Great Lakes, Hudson Bay, and Mississippi River (south to Arkansas) Watersheds. It was formerly abundant in Lake Michigan (to the point where commercial fishermen considered it a nuisance), but today its numbers are greatly reduced throughout its entire range. In Michigan, it is considered a threatened species. Formerly present in at least the lower Chain of Lakes, Lake Sturgeon are now either very rare or absent. Sturgeon which were formerly found in the Chain were probably fish which came from Lake Michigan, but have been excluded by the Elk Rapids Dam since the late 1800's. It typically lives in large rivers and lakes, usually at depths of less than 30 feet. It eats crustaceans, insect larvae (especially midge larvae), leeches, small clams, and snails, using its sensory barbels as an aid in finding food.

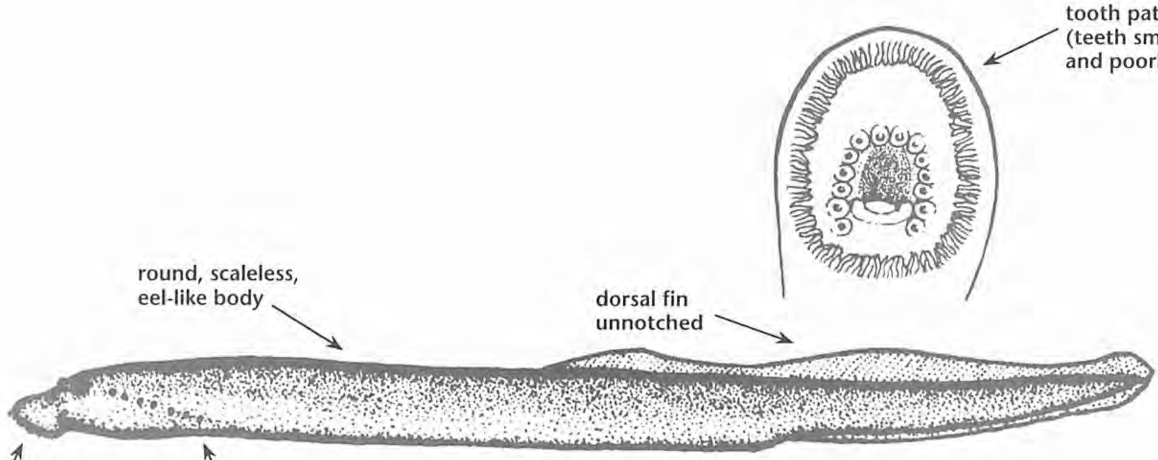
Spawning occurs in late April to early May. Sturgeon do not build a nest, but rather lay their sticky eggs on rocks or boulders in water one to 15 feet deep. Female sturgeon do not spawn until they are 24-26 years old, and then they only spawn once every four to six years. Because they are slow-growing and have a relatively low reproductive rate, they are easily over-exploited.

The young, which are grey or brown on top with blotchy sides, often form large schools; while adults, which are grey or green-grey on top with a white belly, travel in loose aggregations. Sturgeon can live to be more than 100 years old, and specimens nine feet long weighing more than 300 pounds have been documented. They are prized for their meat and eggs (caviar).

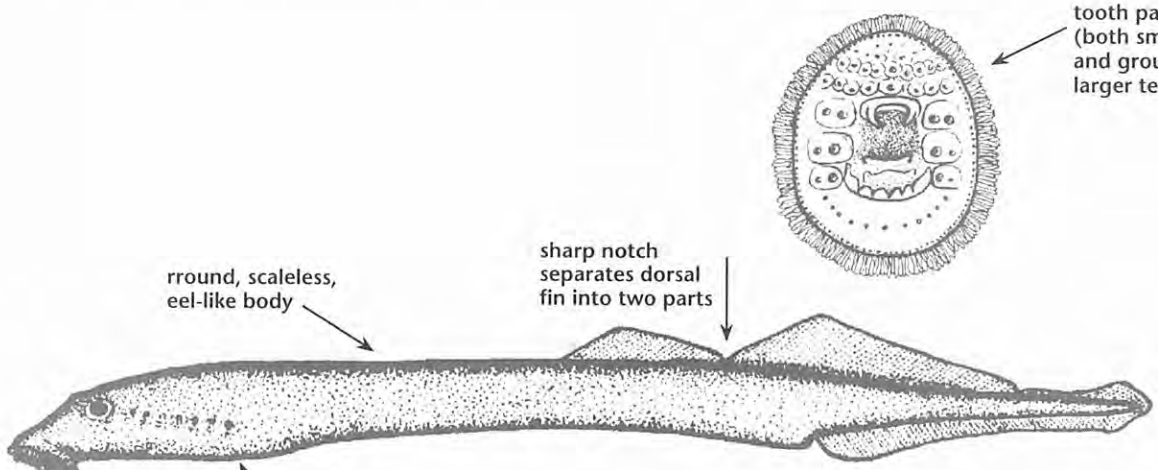
Gar Family

Like sturgeon, gar are also quite ancient, dating back about 45 million years. There are seven species in one genus worldwide (mostly in the Western Hemisphere), and five species in North America, with two of those species found in the Great Lakes Watershed.

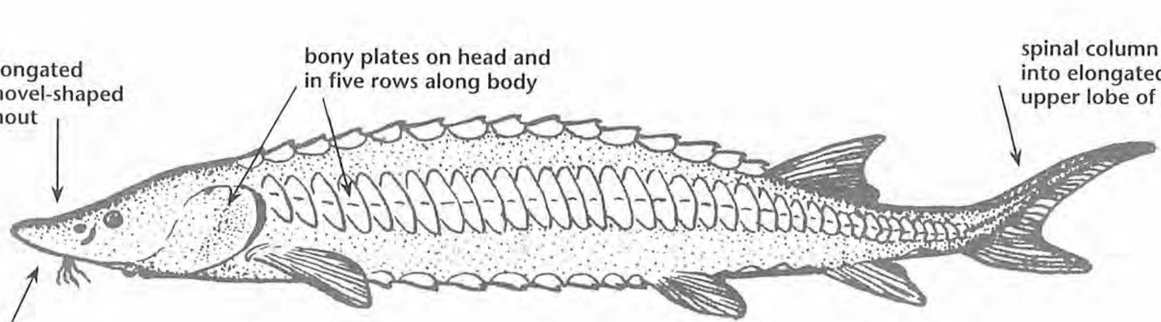
Gar are all long and cylindrical; with a long narrow snout; many needle-like teeth on the upper and lower jaws; and tough, armour-like, parallelogram-shaped scales.



ADULT NORTHERN BROOK LAMPREY
(*Ichthyomyzon fossor*)



ADULT AMERICAN BROOK LAMPREY
(*Lampetra appendix*)



LAKE STURGEON
(*Ascipenser fulvescens*)

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Longnose gar ***Lepisosteus osseus***
(the scientific names mean scales of bone and bony)

The longnose gar is usually olive to dark green on the back, white on the belly, and has round black spots on the rear part of its body and rear fins. The young have a black stripe down the side.

It is found in fresh and brackish waters of North America from Quebec and Montana to the Gulf Coast, including the Rio Grande Watershed (but is absent from New England and the Appalachians). It is most common in the surface layer of the open waters of weedy lakes and reservoirs, and in quiet backwaters of medium to large rivers. Gar like warm water, and are best seen in the Chain in shallow, protected bays which warm up earlier than open lake waters.

Very young gar eat zooplankton, but soon switch to a diet of almost exclusively small fish of many different species. It is most active at night, catching fish by stalking alongside and then striking sideways with an extremely quick motion. During the day, it often rests motionless near submerged or overhanging objects.

The gar spawns from May to early July, when the water temperature hits about 68°F. It usually spawns in weedy shallows, but is also known to spawn in areas of gravel, rocks, or boulders. There is no nest building. A group of males usually attends each female. The eggs, which are green and highly poisonous to humans and many other animals, hatch in three to nine days. The young gar grows rapidly—up to 18 inches in its first year. However, after several years its growth rate slows. Gar can reach more than 50 inches in length, weigh more than 30 pounds, and live for more than 30 years.

The esophagus of the gar is attached to its swim bladder, which can absorb gas and thus act as a kind of primitive lung. This characteristic allows it to survive in waters with extremely low oxygen levels. Under these conditions, it can sometimes be observed breaking the surface every few minutes to ingest air. In the past this species was widely condemned for preying on too many young sport fish. However, studies have shown that young sunfish and non-game species comprise most of its diet. In fact, some fisheries biologists have advocated the stocking of gar to prevent stunting of panfish populations.

The longnose gar is not sought much by anglers, but their meat has been described as "white, boneless, well-flavored, and wholesome," and it "fights like the devil" when hooked. Sometimes, it will steal baitfish from angler's hooks, but is seldom hooked because of its very narrow, bony mouth. The gar is an inactive fish when not feeding. Possibly as a result, it appears to be highly efficient at converting food into flesh. Its tough scales provide armor-like protection, and its skin has been used for decorative and artistic purposes.

Bowfin Family

The bowfin is the lone surviving member of a family of fish which was diverse and prolific 100-200 million years ago.

Bowfin ***Amia calva***
(the scientific names mean an ancient name of a fish, probably the bonito, and bald)

The back and sides of the bowfin are mottled olive green, the belly is yellowish or white, and the lower fins are bright green. Males have a black spot circled with red and orange near the tail. Its skeleton is partly bone and partly cartilage. Bowfin can reach 20 pounds and more than 40 inches long.

It is found in Eastern North America from the Great Lakes and St. Lawrence Watersheds through the Mississippi and Ohio Valleys, south to the Gulf of Mexico, and along the east coast. However, its occurrence in the Great Lakes Watershed may be a result of human introduction. The bowfin prefers lakes and large, sluggish rivers with clear water and abundant vegetation. Adults usually live in deep water, coming into the shallows at night to feed.

Young bowfin eat zooplankton and aquatic insects. The adult primarily eats all types of small fish and crayfish, but it will take advantage of almost any suitable food item.

Spawning in Northern Michigan is from May to early June, when the water temperature is 60 to 65° F. The male builds a nest by clearing away the stems of aquatic plants (by biting them off) and digging a trough in the plant roots in the underlying sand or gravel. Spawning occurs at night when the male and female release eggs and sperm into the trough. Several females may spawn with a single male. The male guards the nest until the eggs hatch (in eight to ten days). The larvae stay in the nest for nine days before swimming away in a dense, ball-like school. The male continues guarding the school of young for about two months, vigorously attacking anything that comes near.

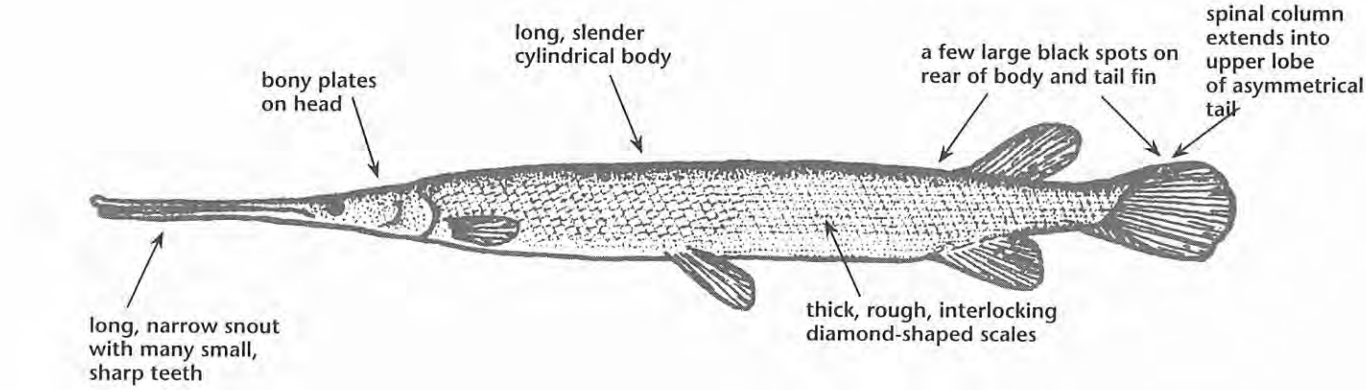
Small bowfin are reported to make interesting and hardy aquarium pets. It can propel itself both forward and backward simply by undulating its dorsal fin. It has been reported to live up to 30 years in captivity. Although some people reportedly eat bowfin, it is generally considered poor table fare. Like the gar, its swim bladder serves as a primitive lung. The rate of air breathing increases with temperature. Bowfin have been known to survive in moist mud for several weeks.

Minnow Family

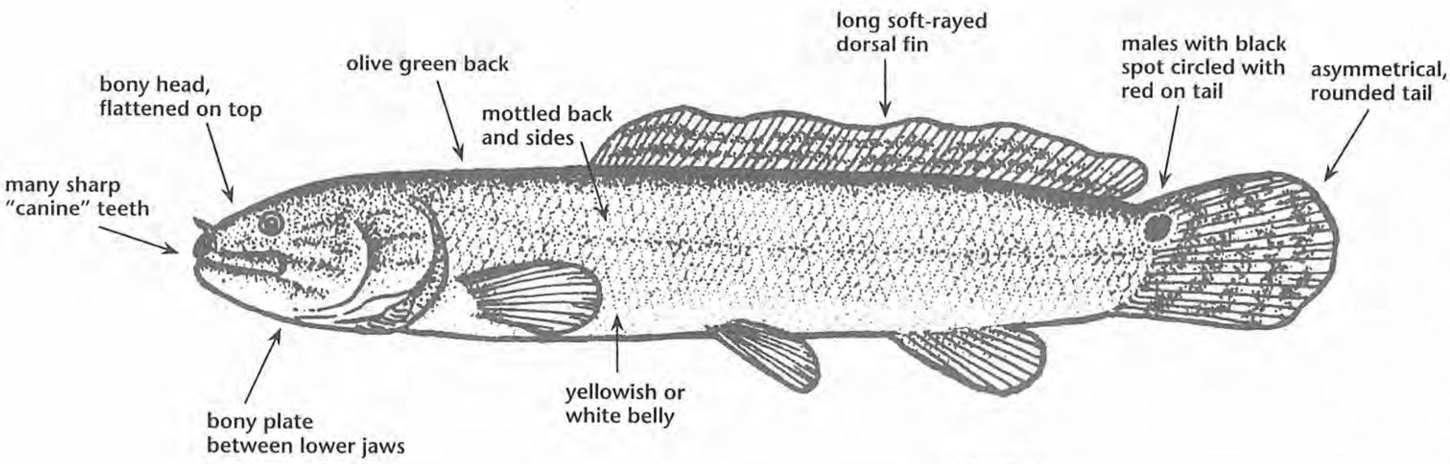
The minnow family originated in Eurasia about 60 million years ago. It is the largest of all fish families, with more than 1,500 species in 275 genera worldwide, primarily found in fresh water. More than 200 species are in North America, and about 76 species in the Great Lakes Watershed. Nineteen species are known from the Chain of Lakes system.

Most native minnows are small, but some species found elsewhere (like the carp, which, fortunately, is not found in the Chain of Lakes) grow quite large. All small fish are often referred to as minnows. However, the minnows are a specific group of soft-rayed fishes with toothless jaws (although they have teeth at the back of their mouth), and well-developed fins and scales. Due to unique bones in their ears, they are thought to have sensitive hearing.

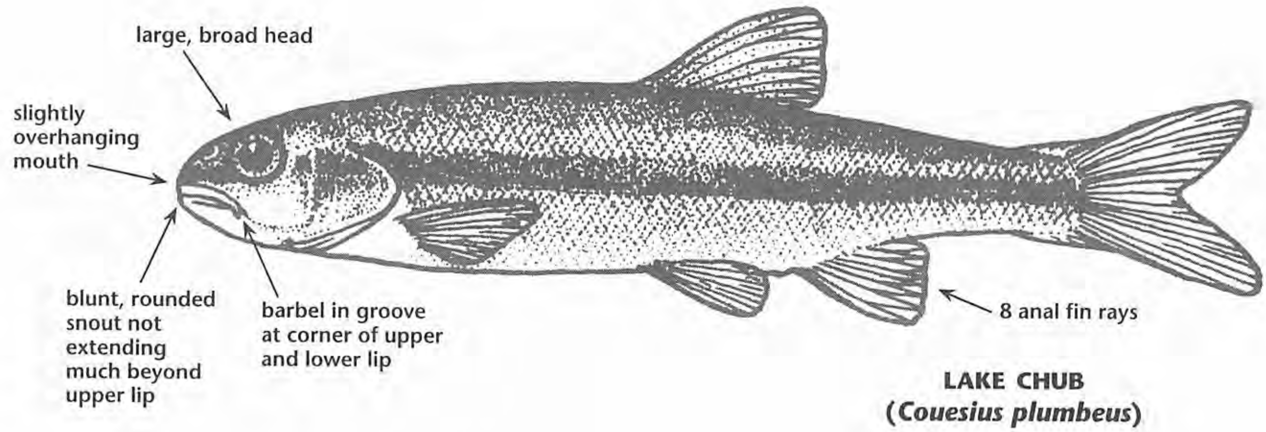
During the breeding season, the males of many species



LONGNOSE GAR
(*Lepisosteus osseus*)



BOWFIN
(*Amia calva*)



LAKE CHUB
(*Couesius plumbeus*)

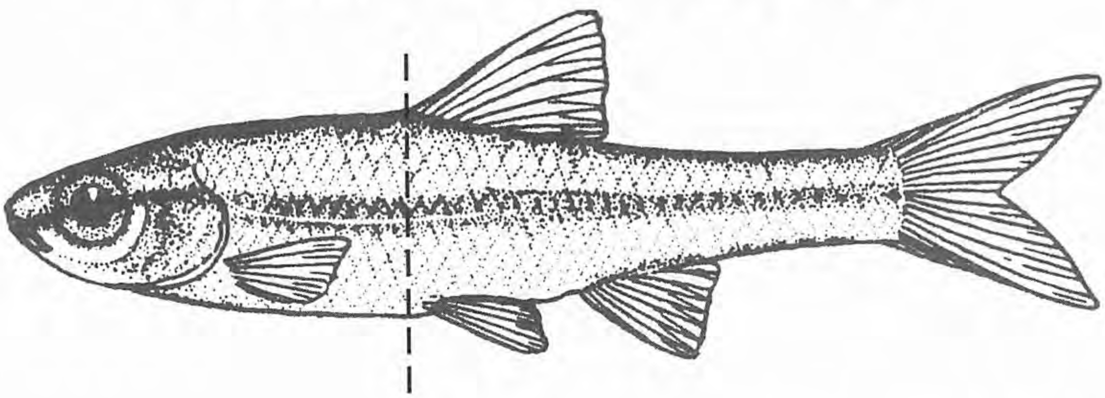
develop bright colors and tubercules (pimple-like bumps) on head, scales, or fins. The breeding males (and in a few cases females) of all the species in the Chain of Lakes develop tubercules, ranging from minute to large and sharp. These tubercules have three purposes: to aid in nest construction, for fighting, and to enable males to hold onto females.

Minnows occur in all types of habitats (e.g., lakes, streams, and ponds), but some have very specific habitats. They are probably all important as forage for larger predaceous fish. They are also important for many types of water-dependent animals, such as herons, turtles, and snakes. They are used extensively for bait, and are both collected from the wild and propagated in ponds (Figure 30). The bait industry in Michigan is now a multi-million dollar business annually. As a group, minnows are prolific, often achieving high numbers in lakes and streams. There are some instances of very abundant minnows being used for fertilizer.

Many species of minnows appear very similar, making identification difficult. To aid with identification, the minnows of the Chain of Lakes have been divided into two groups: those with the front base of the dorsal fin beginning behind the front of the pelvic fins, and those with the front base of the dorsal fin beginning opposite, or in front of, the pelvic fins.

Figure 30 - Although Americans usually think of minnows as bait or forage, in other parts of the world where fisheries are more degraded even small minnows are prized as table fare, as this label from a chinese cannery attests.

For the following eight species of minnows, the front base of the dorsal fin begins opposite, or in front of, the pelvic fins



Lake chub ***Couesius plumbeus***
(the scientific genus name is after Dr. Elliot Coues, an ornithologist, and plumbeus means lead colored)

The lake chub has a lead-grey back and upper sides, and a silvery-white belly. The adult are normally about three inches long, but can reach more than eight inches in length.

It is widely distributed across Canada and the northern tier of the U.S. In fact, it has the most widespread northern distribution of any minnow. It is found in the Great Lakes, large inland lakes, and in streams. In lakes, it is usually found in shallow water, especially around stream mouths. The lake chub prefers cool water, and is often present in waters containing trout, but it can be found in a wide variety of water quality conditions (both clear and turbid).

Little is known about its life history. Young fish eat zooplankton, while older fish eat insects. Spawning occurs in late April to May, when the water temperature reaches 50 to 55° F. It can spawn over a variety of bottom types, from silt and leaves to gravel and rocks. There is no nest construction or parental care. A small number of non-adhesive eggs are released periodically during the spawning season. Most spawning occurs in the afternoon. Eggs hatch in about 10 days. The lake chub can live to be five years old. It is sometimes found in large schools.

Brassy minnow ***Hybognathus hankinsoni***
(the scientific names mean protruding jaw and after T.L. Hankinson, a Michigan ichthyologist)

The brassy minnow has a dark, silvery cast on the back and sides, with a creamy white belly. The body and fins of breeding males take on a brassy color. Its average length is about 2.5 inches, and maximum length about 3.5 inches.

Found primarily in the Great Lakes, Hudson River, and Upper Mississippi Watersheds, it seems to prefer small- to medium-sized streams with a slow current. It will tolerate a wide temperature range, being found in both trout and non-trout waters.

Brassy minnows mostly eat algae (primarily bottom-living species) and organic debris from the bottom, but are also known to eat zooplankton, insects, and "animal remains." The microbes in organic debris are probably an important food source. However, it appears to be opportunistic, eating any living or dead food item that can be swallowed. It seems to feed most in the afternoon when water is warmest.

Spawning season begins when the water temperature reaches about 58 to 62° F., and lasts seven to ten days. Spawning takes place in an area of vegetation, with one or more males attending each female. There is no nest building or parental care. The slightly adhesive eggs stick to the vegetation. Few fish live to be three years old.

The brassy minnow is a schooling fish, and is generally inactive during the winter months. Greatest abundance occurs where there are few predators. It is often collected and sold as bait.

Common shiner ***Luxilus cornutus***
(the scientific names mean bright light, probably in reference to its silvery color, and horned)

The common shiner has a light olive-green back, silvery sides with scattered dark scales, a white-silver belly, and a broad stripe on the top of the back. Breeding males develop a blue-grey head and back, a pinkish color on the sides and fins, and large tubercles on the head and snout. Average adult length is about three inches, but it can reach lengths of eight inches.

Widely distributed from Nova Scotia south to the James River Watershed in Virginia, west through the Great Lakes Watershed to Saskatchewan and south throughout the northern half of the Mississippi Watershed, common shiners are usually found in clear lakes and streams. As its name implies, it is one of the most common minnows of streams and rivers. In lakes, small common shiners seem to prefer nearshore shallows, while larger fish are found farther offshore in small schools cruising above beds of aquatic plants. It is adapted to a wide range of water temperatures.

Studies have indicated that it eats mostly plants, such as diatoms, filamentous algae, and parts of larger plants. It also eats insects and other fish. The common shiner seems to be a preferred food of smallmouth bass.

Spawning occurs from late May to late July in stream riffles over gravelly bottoms, or in gravel shoals in lakes, when the water temperature reaches 60-65° F. Spawning lasts abut 10 days and occurs during daylight. Males may or may not build a nest (sometimes utilizing nests built by other fish), but always seek areas of current. During spawning, males establish territories which they defend by rushing at, or butting, intruders. When a female enters the male's territory, he clasps her with his fins, and eggs and sperm are released. The eggs become adhesive after about two minutes in the water, and stick between the pebbles in the bottom of the nest.

Common shiners take two or three years to mature, but seldom live longer than six years (although ages of nine years have been recorded). It is one of the most common species sold as bait.

Blackchin shiner ***Notropis heterodon***
(the scientific names mean back or keel and varying teeth in reference to tooth number)

The blackchin shiner is silvery-yellow on the top half, silvery-white on the bottom half, with a dark lateral stripe extending from the tail through the eye to the head. It can reach a length of up to 2.8 inches long.

It occurs primarily in the Great Lakes Watershed and in a few outlying areas of the Upper Mississippi Watershed. It prefers clean, clear, weedy lakes and streams, usually in close association with vegetation. It has disappeared in many portions of its former range, possibly due to sedimentation. It can apparently withstand low dissolved oxygen levels.

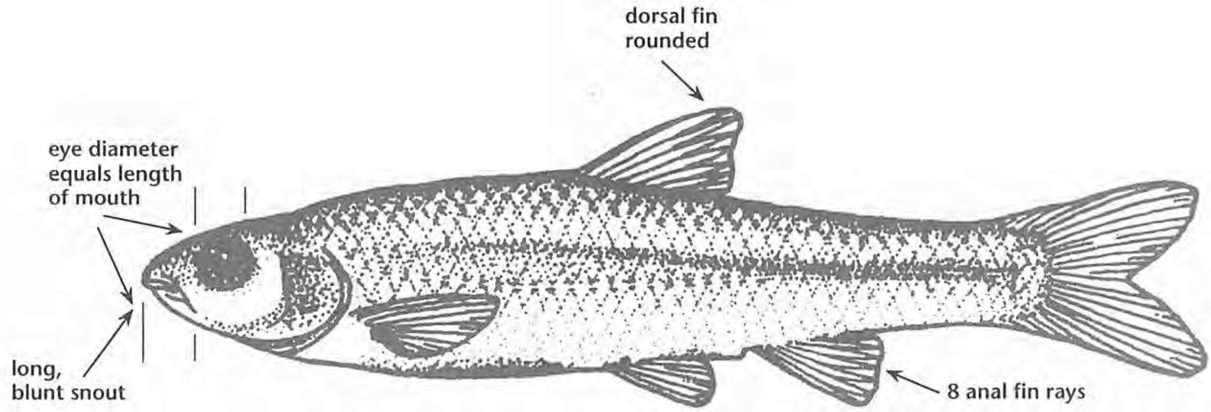
It eats mostly zooplankton, aquatic insects, and other invertebrates. It appears to feed mostly on things living in and on vegetation rather than on the bottom. The blackchin shiner spawns from June to August. It becomes sexually mature when one year old and spawns annually. Blackchin shiners up to three years old have been collected. However, little is reported in the literature about its spawning habits and early life history.

Blacknose shiner ***Notropis heterolepis***
(the scientific names mean back or keel and varying scale)

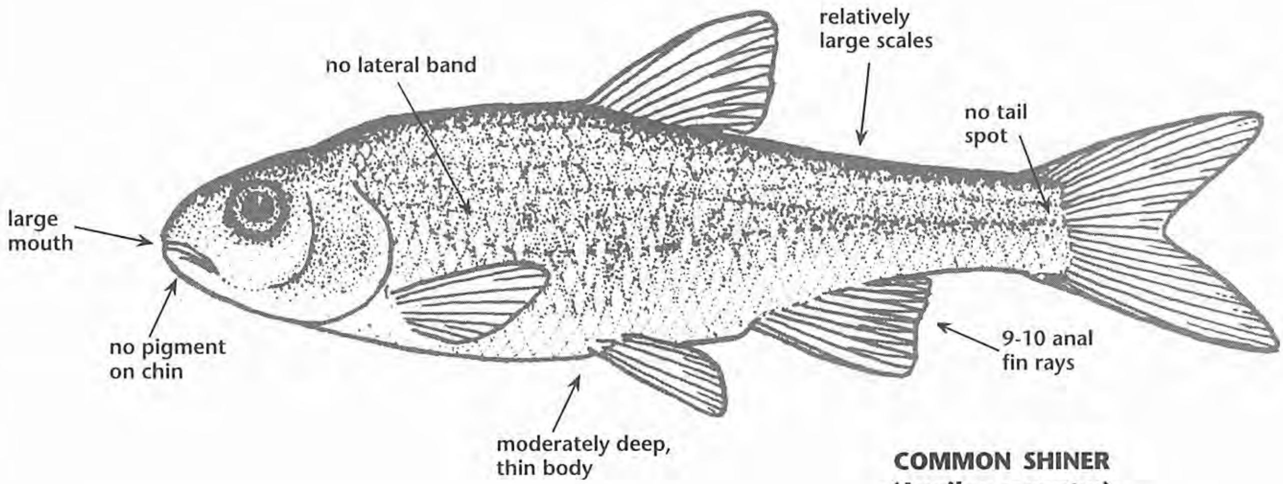
The blacknose shiner has a silvery olive-yellow back, a dark lateral stripe extending around its nose (hence the name), but not onto the lower lip and chin (which are white), silvery sides, and a silvery white belly. The largest specimen collected was about four inches long.

It is found in small lakes, streams, and in protected bays of larger lakes in the watersheds of Hudson Bay, the Great Lakes, the Upper Mississippi and Ohio Rivers, and the New England states. Populations are actually widely scattered within its range, and it is declining in many areas. It requires clear, vegetated waters, and sedimentation is suspected in its decline. Populations seem to fluctuate a great deal.

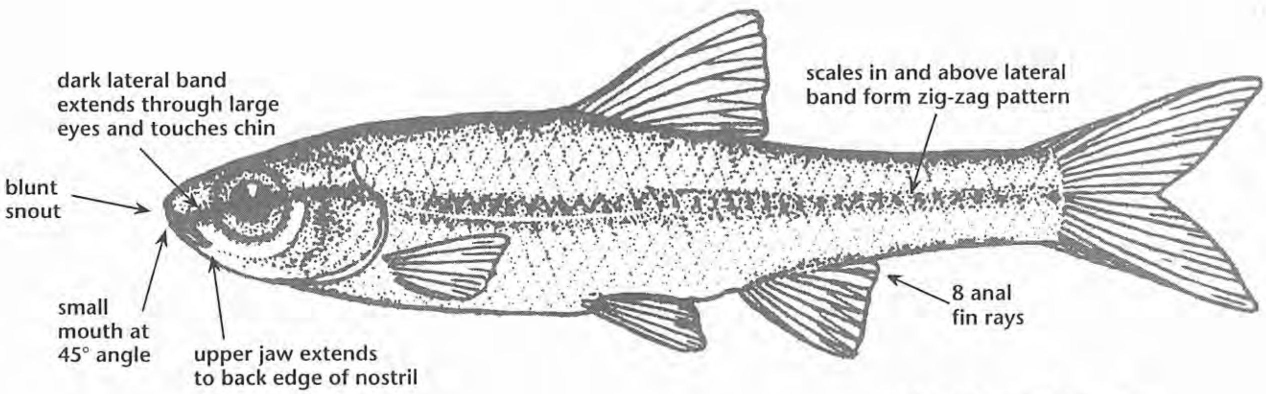
Spawning requirements and behavior are unknown, but it is suspected that the blacknose shiner spawns over sandy bottoms. It becomes sexually mature at one year of age and spawns annually. Its life span is unknown. Zooplankton, insects, plant materials, and fish eggs have been found in its stomach. The downward-facing mouth and the short digestive tract suggest that it mostly feeds on animals on the bottom.



BRASSY MINNOW
(*Hybognathus hankinsoni*)



COMMON SHINER
(*Luxilus cornutus*)



BLACKCHIN SHINER
(*Notropis heterodon*)

Spottail shiner *Notropis hudsonius*
(the scientific names mean back or keel and after the Hudson River)

The spottail shiner is pale silvery olive on the back, silvery on the sides, and silvery white on the belly. It has a black spot the size of its eye's pupil at the base of its tail fin (which may be obscured by scales on larger fish). It can reach a length of about 5.5 inches.

It is found in the Upper St. Lawrence, Great Lakes, Hudson Bay, and Upper Mackenzie River Watersheds and the Atlantic coast of the U.S., from the Hudson River to Georgia. It is most common in large inland lakes and in large slow-moving rivers. In some areas its numbers seem to have been depleted due to commercial exploitation.

Small spottail shiners eat mostly plankton. Larger specimens eat fish eggs, aquatic insect larvae, terrestrial insects, and sometimes algae and other plant material. They are reported to feed most actively just before sunset, and to move into the shallows at night. These shiners apparently move around a lot, possibly in search of the ideal temperature. They have been captured in depths of 150 feet.

This species spawns in late May and early June. It spawns in groups in gravelly or sandy nearshore areas. It does not build a nest. It grows only during the warmest portion of the year-- from May to October. The spottail shiner matures at age one or two, when they reach a length of about 2.5 inches, and can live to be five years old.

Sand shiner *Notropis stramineus*
(the scientific names mean back or keel and without a chin)

The sand shiner has an olive yellow back with dark-edged scales, silvery sides, and a silvery-white belly. Its lateral line pores are bounded by paired spots resembling mouse tracks. It has a well defined mid-dorsal stripe, which is interrupted by the dorsal fin, a short lateral stripe near the tail, and a small spot at the front edge of the tail fin. Except for its dorsal fin position, it is very similar in appearance to the mimic shiner. Its average length is 2.4 inches, and it can reach a length of about 3.5 inches.

It is found throughout Central and Southern North America and parts of the Western Gulf Coast to Northern Mexico, including the Upper St. Lawrence, Great Lakes (except Lake Superior), Mississippi River, and Red River Watersheds. It is most common in medium- to large-sized streams. It also inhabits lakes, but not frequently in large numbers. In lakes, it is found in mid-water or on the bottom during the day (it has been found in depths of more than 100 feet), moving to the surface or into shallows at night. In rivers during winter, it mostly remains under nearshore ice cover. It seems to have decreased in some areas, possibly due to sedimentation of the water.

Sand shiners have been found to eat algae, zooplankton, insect larvae, a variety of bottom-dwelling invertebrates, and organic bottom sediment. Spawning season is from late May to mid August. In lakes, it spawns in nearshore shallows, usually under the protection of submerged vegetation. However, little is known about its spawning behavior and early development. It spawns at the age of one, and can live for three years. It is a schooling fish—schools up to 5,000 have been observed. It can tolerate low levels of dissolved oxygen.

Fathead minnow *Pimephales promelas*
(the scientific names mean fat head and black in front)

The fathead minnow's back, and its sides down to the lateral line, are a dark olive green. Below the lateral line its body is whitish in color with the dark lining of the body cavity showing through. Males develop a black head and the rest of the body darkens during spawning. Its average length is about two inches, and its greatest length is about four inches.

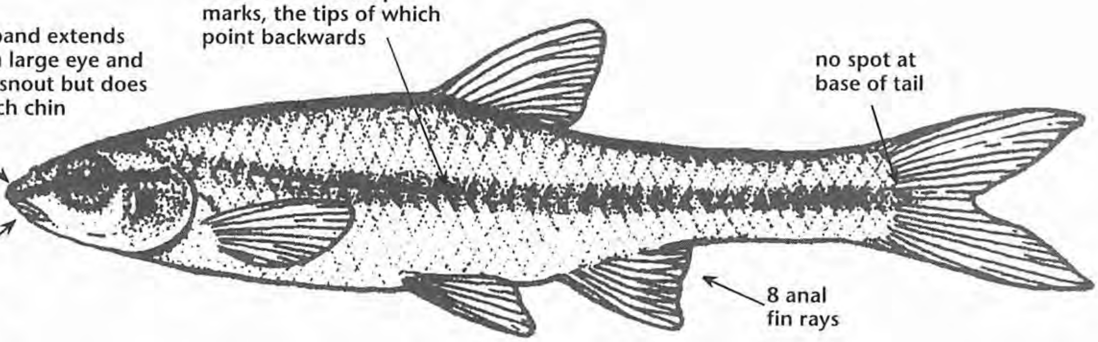
It ranges throughout most of Central North America, including the Upper St. Lawrence, Great Lakes, Lower Hudson Bay, Mississippi River, and Red River Watersheds. It is common to abundant and widely distributed within that range. The fathead minnow prefers ponds; boggy lakes; and low-gradient, silty streams and ditches. It is usually most abundant where there is a lot of floating and submerged algae. Preferred water temperature is about 72° F. Considered a very hardy species, this species is very tolerant of pollution, heavy silting, and low oxygen levels.

The fathead minnow is considered an opportunistic feeder. Its food consists of algae, rooted aquatic plants, zooplankton, and insect larvae. It is least abundant in lakes with a lot of predaceous fish.

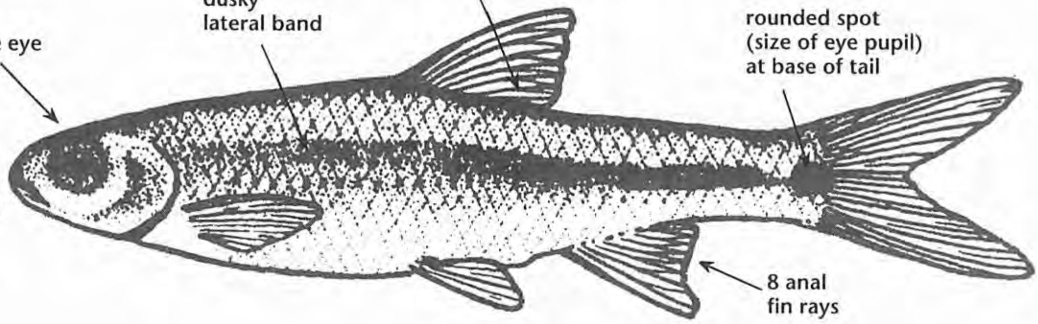
Spawning begins in late May and early June and lasts until mid August. The male fathead minnow builds a nest by excavating a shallow cavity on the underside of a flat object (like a rock or log) on a sand or marl bottom. If there are no natural objects, it will utilize human artifacts, such as concrete, wood, tar paper, or cans for spawning sites. It creates the excavation by sweeping away silt with its tail, or pushing out larger objects with its snout, and scraping the underside of the object with the horny knobs which develop on its head during spawning. The female lays her eggs on the underside of the object in about 2.5 feet of water. Males defend the nest. Fathead minnows die within 30-60 days after spawning; most fathead minnows do not live two years.

It's growth rate is rapid, and it may reach adult size by the end of summer. It has been known to spawn later in the same season in which it was hatched—a circumstance unique among fish of the Northern U.S. Males grow more rapidly, and to a larger size, than females. It is considered highly prolific. In one instance, 100 pounds of fathead minnows stocked into a sewage treatment pond yielded 7,200 pounds less than four months later.

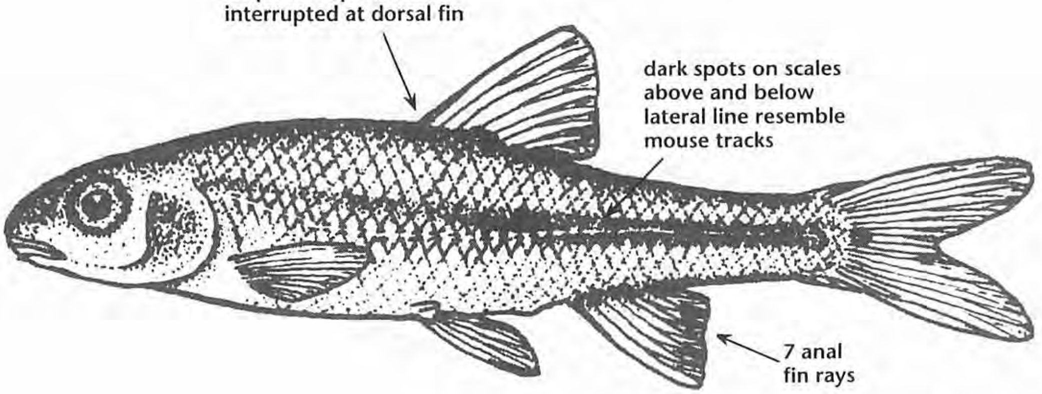
The fathead minnow is used extensively for laboratory studies on the effects of toxic substances. It has also been used successfully as a natural mosquito control by stocking in shallow areas where mosquitos breed.



BLACKNOSE SHINER
(*Notropis heterolepis*)

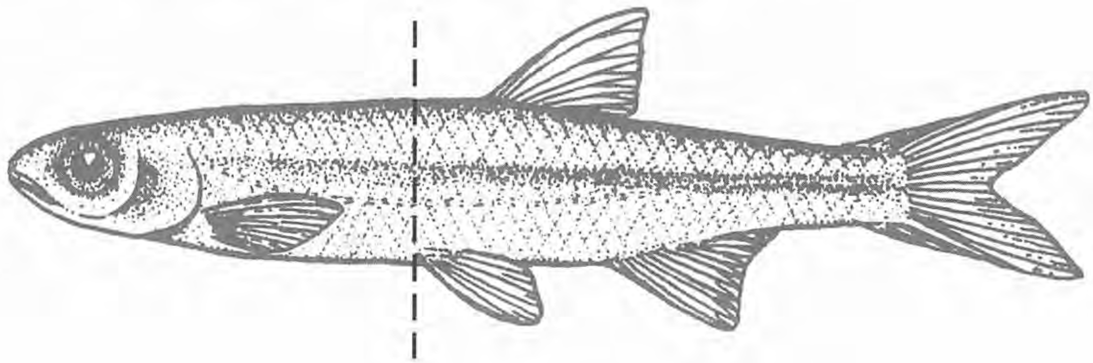


SPOTTAIL SHINER
(*Notropis hudsonius*)



SAND SHINER
(*Notropis stramineus*)

For the following eleven species of minnows, the front base of the dorsal fin begins behind the front of the pelvic fins



Creek chub ***Semotilus atromaculatus***
(the scientific names mean spotted banner in reference to the dorsal fin, and black spot)

The creek chub is dark on the back, lighter on the sides, and the belly is silvery white. A dark spot is located on the dorsal fin near its front base. Young have a dark lateral stripe, which disappears in older fish. The average length of the creek chub is about four inches, but it can grow to be more than 12 inches long.

Found from the Great Plains eastward throughout the U.S. and Southern Canada, it is abundant in small- to medium-sized streams and rare in larger streams and in lakes. It prefers clear waters.

Creek chubs, especially larger individuals, are opportunistic carnivores, eating whatever organisms are available from bottom-dwelling insects to small fish.

Spawning occurs from May to July when the water temperature reaches about 55° F. It spawns in gravelly areas in the current. The male excavates a small pit in the gravel, picking up larger stones in his mouth and carrying them to the upstream edge of the pit. The male defends the nest against other males. When a female enters the nest, the male clasps her by curving his body around hers and flips her into a vertical position. In less than a second, eggs and sperm are deposited and the female is released and floats motionless for a few seconds (apparently stunned by the experience). Eggs are then covered with gravel by the male.

Young creek chubs sometimes grow 3.5 inches in the first year. They can live up to six years. This minnow is a schooling species when small, becoming more solitary as it gets larger. It is a popular bait minnow. It bites readily on bait or small lures, and is often incidentally caught by trout anglers.

Northern redbelly dace ***Phoxinus eos***
(the scientific names mean tapering and sunrise)

The northern redbelly dace has a distinct lateral stripe running from the snout to the tail, as well as another stripe on the upper back and a single stripe on the top of the back. Its back is dark olive green, with silvery-white lower sides and belly. Breeding males develop intense red or bright yellow abdomens. Its brilliant breeding colors are said to surpass the splendor of many tropical fishes. Maximum size is about three inches.

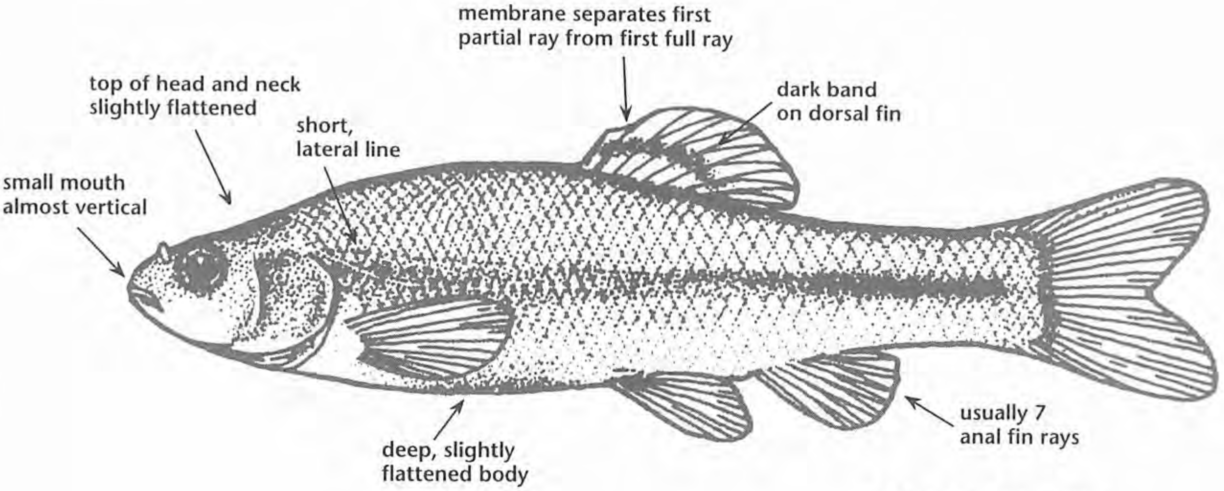
Found from the Great Lakes, Upper Mississippi, and Lower St. Lawrence Watersheds north to Hudson Bay, with another population on the eastern slope of the Canadian Rockies, it is abundant in small streams, beaver ponds, and bog lakes. The redbelly dace is often associated with vegetation and mucky-silty bottoms. It lives in both cold and warm water streams. Its food consists mostly of diatoms and filamentous algae, but it also feeds on zooplankton and aquatic insects.

Most spawning occurs in June and July. One female is attended by several males. The female wriggles into a mass of filamentous algae, followed by the male, where non-adhesive eggs are deposited throughout the filaments. There is no parental care. It is reported to do well in aquariums. Most fish do not live past three years, although fish up to eight years old have been reported.

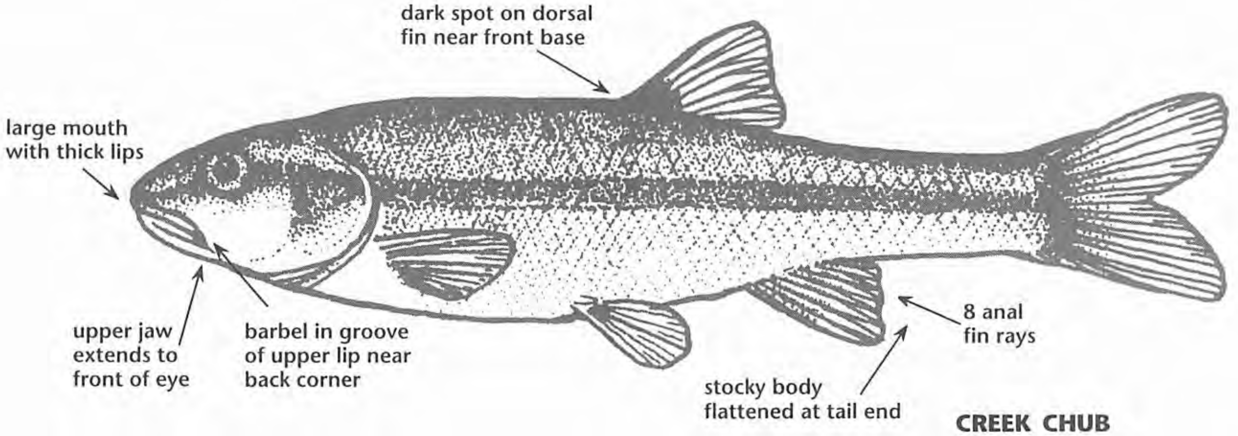
Pearl dace ***Margariscus margarita***
(the scientific names both mean pearl, possibly in reference to their lustrous appearance)

The pearl dace has a dark or dusky silver color (darkest on back and more silvery on the sides) with a dusky lateral stripe, especially in the young. Breeding males develop a reddish orange stripe along the flank below the lateral stripe. This stripe can develop in late summer and persist until the next spring. Breeding females develop a lighter (yellow to orange) colored stripe. The average length is about 3.5 inches, with the largest on record being 6.5 inches.

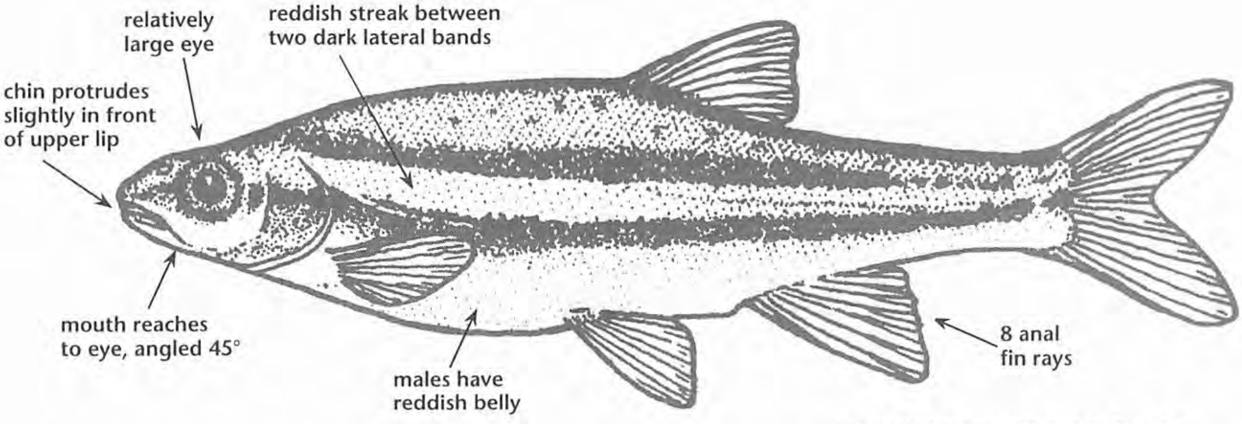
Found throughout most of Canada and the northern tier of the U.S., it is most commonly found in cool, clear, small headwater streams. It is less common in lakes and medium to large rivers. It is often associated with brook trout and



FATHEAD MINNOW
(*Pimephales promelas*)



CREEK CHUB
(*Semotilus atromaculatus*)



NORTHERN REDBELLY DACE
(*Phoxinus eos*)

mottled sculpin. Insects are its preferred food, but it has also been known to eat phytoplankton, mollusks, and water mites.

Spawning occurs in April or later when the water temperature reaches about 62° F. Males guard a spawning area in gravel or sand, but do not construct or excavate a nest. Pearl dace mature at age two. Studies have failed to find three-year-old males, and it may be that all males die after spawning. A few females live as long as four years.

Golden shiner *Notemigonus crysoleucas*
(the scientific names mean angled back half, in reference to the keeled underside, and gold or white)

The golden shiner has a gold-green back, silvery-golden sides, and a yellowish or silvery-yellow belly. Golden shiners can reportedly grow to be 12 inches long and weigh 1.5 pounds. Bait shops often sell them under the name of grey shiner.

Found in the eastern half of North America, from the Canadian Maritimes south to Florida and west to the Dakotas and Texas, it generally inhabits warm, shallow waters. However, larger specimens have been noted in water five to 12 feet deep without much aquatic vegetation. Because of its widespread use as bait, it has been introduced into many areas where it was not native.

It is thought to primarily use sight to find and capture its food, which consists mostly of zooplankton, insects, and aquatic vegetation (about 20% of its diet). Its angled mouth is adapted for surface and open-water feeding.

Spawning begins when the water reaches 68° F. and continues throughout much of the summer. Spawning occurs over beds of submerged vegetation. One or two males pursue a single female, and she drops eggs as she swims. The eggs, which cling to the vegetation and to nearby stones, hatch in about four days. Aquarium specimens have lived for 10 years. Females grow faster and live longer than males.

The golden shiner is tolerant of low oxygen levels, and is able to survive for extended periods when the oxygen level drops to around one part per million. It is a desirable bait fish, but it is delicate and does not survive well in a bait bucket. It has been used successfully as a natural mosquito control by stocking in shallow areas where mosquitos breed.

Emerald shiner *Notropis atherinoides*
(the scientific names mean back, or keel and silverside-like)

The emerald shiner has an iridescent silvery blue-green back, silver sides, and a silvery-white belly. It is commonly sold in bait shops under the name "blues," and has also been referred to as lake shiner. It can reach a length of almost five inches.

It is found in the Upper St. Lawrence River, Mackenzie River (Canada), Great Lakes, Mississippi, and Hudson Bay Watersheds; and parts of the Gulf Coast. It is common in large inland lakes and large rivers. It was formerly extremely abundant in Lake Michigan, but it is now rare there due to competition with the alewife, an exotic species. It is found at mid-depths or at the surface in clear, offshore waters. Its preferred water temperature is 77° F.

The emerald shiner primarily eats zooplankton, phytoplankton, and insects. It is known to feed at night on small flies hatching on the lake surface. Many fish-eating birds eat emerald shiners because their open-water, surface-feeding habit makes them particularly vulnerable.

The emerald shiner spawns in summer (late May through early August), when the water reaches about 72° F. It spawns on gravel shoals, but will utilize boulders, rocks, or sand. Spawning occurs offshore at night in depths of seven to 20 feet in schools that can number millions of fish. Fertilized, non-adhesive eggs sink to the bottom where they hatch in 24-32 hours. It can live up to four years. Females live longer and grow larger than males.

Rosyface shiner *Notropis rubellus*
(the scientific names mean back or keel and reddish)

The rosyface shiner has a silvery color with an olive yellow cast on the top half and whitish on the bottom half separated by a lateral stripe which narrows and darkens toward the tail. Breeding males develop an orange-red cast, especially on the head and fins. A bead-like iridescent emerald line runs the length of the body above the lateral line. It can reach a length of about 3.5 inches.

The rosyface shiner ranges throughout the Great Lakes (except the Lake Superior portion), the Upper St. Lawrence, and the Mid- and Upper-Mississippi Watershed; and the Atlantic Coast from the Hudson River to Virginia. It is generally found in medium-sized, clear, swift streams. It is uncommon in lakes.

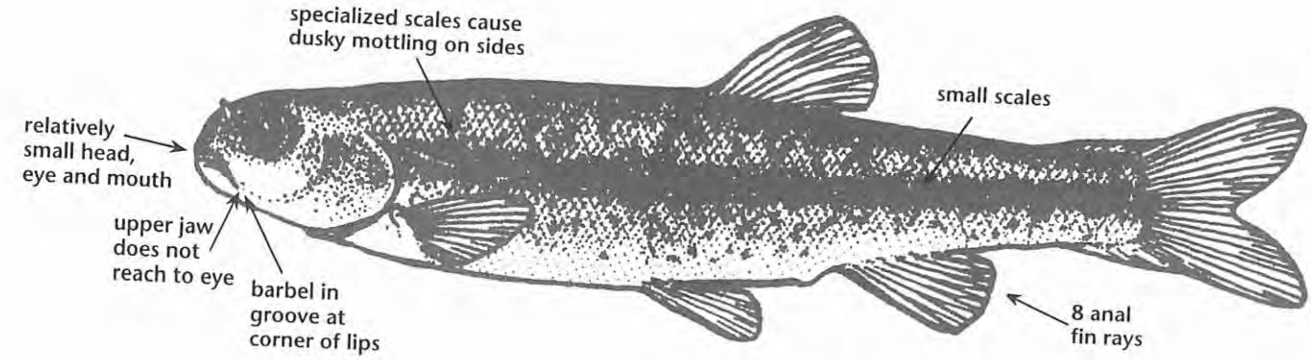
The rosyface shiner eats a wide variety of food items, but the young mostly eat algae, and older fish mostly eat insects. It becomes inactive during winter (November until March), ceasing to feed and living in the deepest pools. It is primarily a sight-feeding fish. It does not feed during any particular time of day, and has been observed feeding both at the surface and on the bottom.

This species spawns in May and June, whenever the water reaches about 70° F. Spawning occurs during bright, sunny days. It often utilizes nests made by other minnows. Spawning occurs in groups of eight to 12 fish suspended several inches above the bottom. Males display some aggressive behavior toward each other, but do not guard territories. The eggs sink and stick to the first object they encounter. Unattended, they hatch in about two to three days. The rosyface shiner can live about three years.

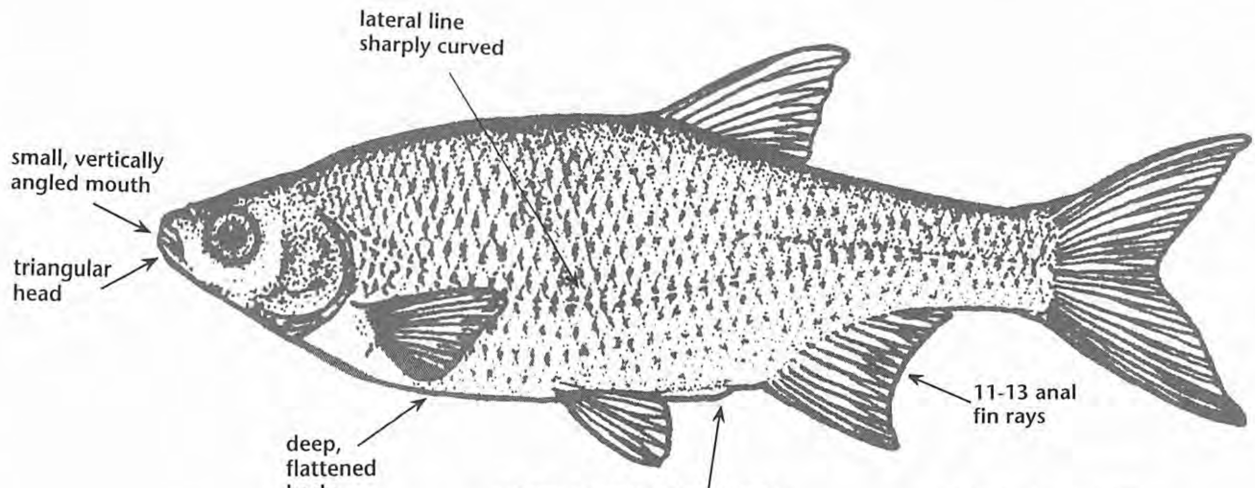
Mimic shiner *Notropis volucellus*
(the scientific names mean back or keel and swift)

Above the lateral line, the mimic shiner is olive-yellow and the scales have dark edges. Below it is whitish. Its lateral line pores are bounded by paired spots resembling mouse tracks. It has a stripe at the top of the back consisting of several faint parallel lines. It also has a faint lateral stripe near the tail, and has black pigment along the base of the anal fin and around the anus. Except for the configuration of the dorsal fin, mimic shiners are similar in appearance to sand shiners. Its average length is about two inches, with a maximum size of about three inches. Males are smaller than females.

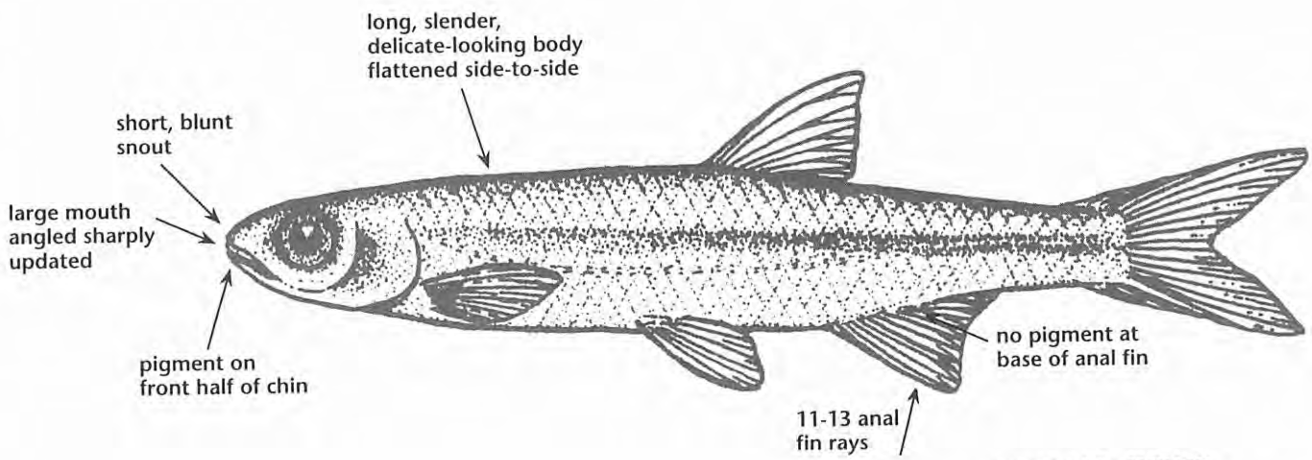
The Mimic Shiner is found in the Upper St. Lawrence River, Great Lakes, Lake Winnipeg, Mississippi River (excepting the Missouri River portion), and parts of the



PEARL DACE
(*Margariscus margarita*)



GOLDEN SHINER
(*Notemigonus crysoleucas*)



EMERALD SHINER
(*Notropis atherinoides*)

Hudson Bay Watersheds; and along the Gulf Coast from Alabama to Northern Mexico. It inhabits medium to large warm-water streams and the shallow water of clear, moderately weedy lakes.

An extensive study of its food habits in Minnesota found that mimic shiners fed heavily on selected species of mid-water zooplankton in early morning, emerging aquatic and terrestrial insects in mid-day, and submerged insects and other invertebrates during evening. It is a schooling fish, with schools commonly swimming back and forth along the shore during the day, but breaking into smaller groups and moving further offshore during evening. At night, it has been observed lying scattered about on the bare areas of the bottom at depths to 25 feet.

It spawns from May through July. Its spawning habits are unknown, but it is thought to broadcast its eggs at night in relatively deep, weedy areas. It spawns at one year of age and can live to be three years old. Its populations appear to fluctuate a lot.

Finescale dace *Phoxinus neogaeus*
(the scientific names mean tapering and new world)

The finescale dace has a stripe at the top of its back and along each side (beginning on the snout, running through the eye, and terminating in a spot near the tail). The fin rays are edged in dark pigment. Its color is dark brown on the back, changing to light olive on the upper sides, with a silvery-white lower half. The average length is about 2.4 inches, but it can reach 4.5 inches.

It ranges throughout the Canadian Maritime Provinces, the Upper St. Lawrence, Great Lakes, and Lower Hudson Bay Watersheds, as well as the eastern slopes of the Canadian Rockies. It is found most commonly in small, sluggish, stained streams and in small, boggy lakes. It seems to be found often in waters where other fish are not abundant.

Small clams and snails seem to comprise a large portion of this minnow's diet, along with insects and other small invertebrates. It spawns from April to June, when the water temperature reaches about 52° F. During spawning, males chase females into depressions under logs and branches in 1.5 to three feet of water. Males do not build nests or defend territories. The finescale dace spawns at two years of age, and can live to be six. It is a schooling fish.

Bluntnose minnow *Pimephales notatus*
(the scientific names mean fat head and spotted)

The bluntnose minnow is generally light olive green on the back, with silvery sides, and a silvery white belly. Its fins are often tinted yellowish or olive. There is a dark blotch in the lower front part of the dorsal fin, and a faint lateral stripe about as wide as its pupil. Its average length is 2.5 inches, and it reaches a maximum of 4.3 inches.

The Bluntnose minnow's range includes the Upper St. Lawrence River, Hudson River, Great Lakes, Red River, and Mississippi River Watersheds, as well as a portion of the Mid-Atlantic Coast. It is one of the most common, widespread minnows in the Lake Michigan Watershed. It is found in lakes, ponds, and rivers in a variety of habitats, but often associated with submerged vegetation. During winter it can be found as deep as 60 feet, but it primarily inhabits shallow water during summer.

It is primarily a bottom feeder, eating a variety of insects, tiny crustaceans, fish eggs, diatoms, and filamentous algae. However, it also eats insects from the surface and plankton.

Spawning occurs from May until August, when water temperatures are between 70 and 79° F. The male bluntnose minnow builds a nest by excavating a shallow cavity on the underside of a flat object (like a rock or log) on sand or gravel shoals in water a few inches to eight feet deep (like described for the closely related fathead minnow). The male guards the nest against intrusion by lunging at other fish (except females) with his horny head, like a tiny bull. Several females may spawn with a single male, their buoyant, adhesive eggs sticking to the underside of the object. After spawning, the male performs the crucial role of guarding the eggs from predators and keeping water moving over the eggs, which hatch in six to ten days. Females mature in one year, males in two, and they can live about three years.

The bluntnose minnow is only active during the day, resting quietly on the bottom at night. It often forms small schools of 10-20 fish. It seems to have a keen sense of smell. Bluntnose minnows are widely cultured in ponds, and up to 105,000 fish (250 pounds) per acre have been raised. It is widely used for bait.

Blacknose dace *Rhinichthys atratulus*
(the scientific names mean snout fish and clothed in black, as for mourning)

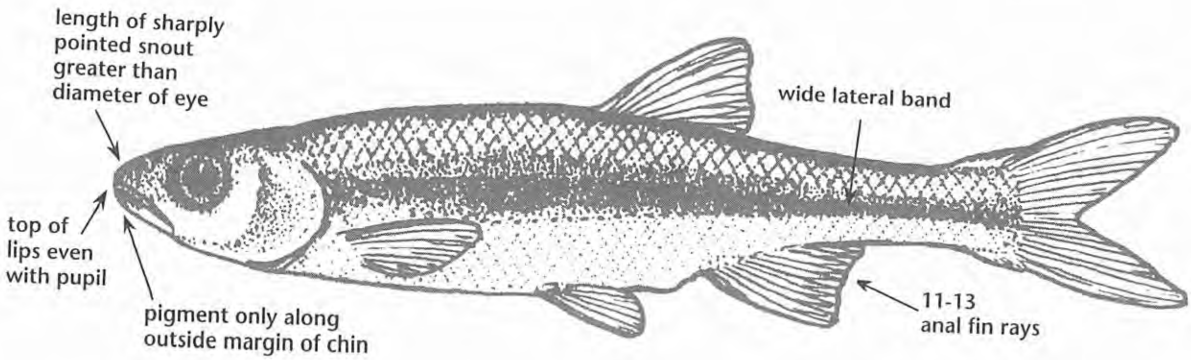
The blacknose dace is brownish-black on its upper half with black blotches. Its lower half is silvery with black spots. It has a white belly. The young have a distinct lateral stripe, which fades in adults. There is a back spot at the base of the tail fin, and its fin rays are "etched" with dark pigment. Breeding males develop a reddish lateral stripe. Its average length is about 2.5 inches, and it has been known to reach four inches.

Found from the Atlantic Coast west through the Great Lakes and Lake Winnipeg Watersheds and in the Mississippi River system south to Mississippi, it is common to abundant in the small, cool, swiftly flowing headwaters of streams. It is often associated with trout in streams, but appears to tolerate somewhat higher temperatures than trout.

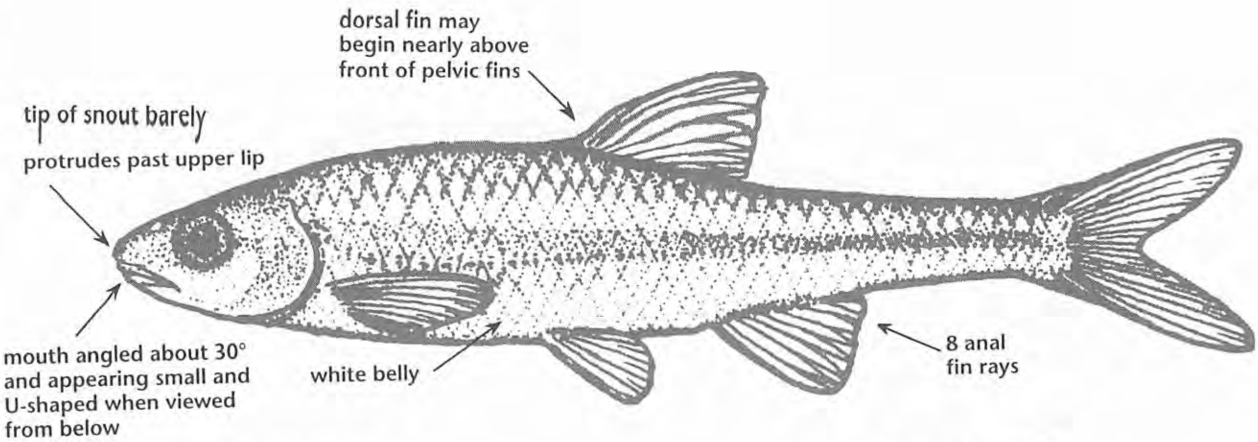
The blacknose dace eats mostly aquatic insects, including mosquito and blackfly larvae, but it also eats diatoms and other algae, and small crustaceans. Some research shows that the plant material is not digested much, and is of little nutritional valve. It also eats its own eggs and the eggs of other species.

Spawning occurs in May and June in areas of sand or fine gravel. Males may guard their spawning site, and combat may break out between pairs of males. Males force the female's body into the sand, and both vibrate violently, at which time eggs are released. Most spawning activity occurs in late morning. The blacknose dace matures late in its second year and can live about three years.

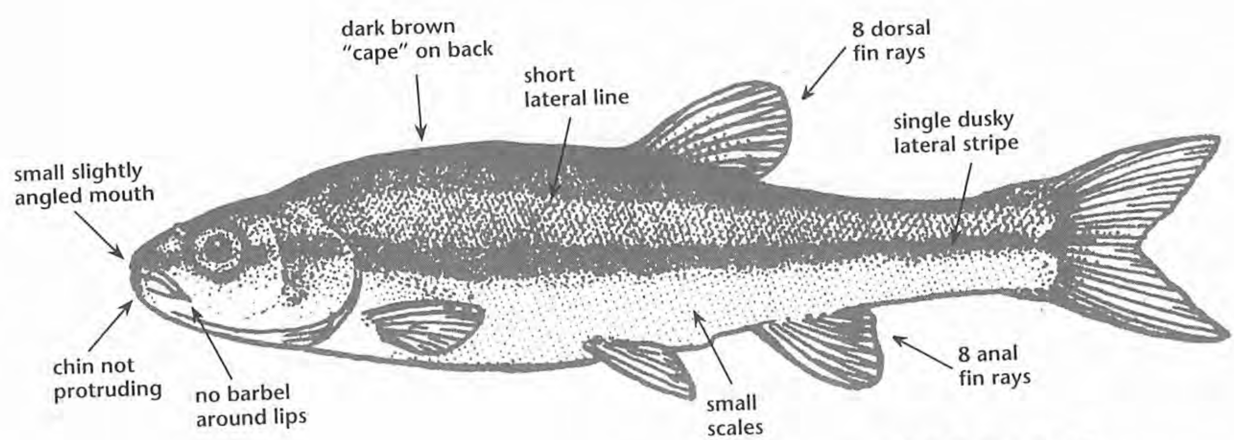
The blacknose dace is a very agile, active fish, darting



ROSYFACE SHINER
(*Notropis rubellus*)



MIMIC SHINER
(*Notropis volucellus*)



FINESCALE DACE
(*Phoxinus neogaeus*)

from one resting place to another (often behind a stone in the current). It is difficult to capture in a net. The largest fish seem to occupy the deepest pools. In winter, it lies close against the banks in deep water. It forms loosely knit schools.

Longnose dace *Rhinichthys cataractae*
(the scientific names mean snout fish and of the cataract—the original specimen being described from the Niagara Falls area)

The longnose dace has a brownish to olive green back (although specimens from large lakes tend to be more greyish), lighter sides, and a silvery white belly. The back and sides are given a mottled appearance by scattered darker scales. Young have a dark lateral stripe which broadens to a blotch in front of the tail fin. However, the stripe fades in adults, leaving only a remnant ahead of the eye. When viewed from above, it can be distinguished by two white spots on its back—at the front of the dorsal and tail fins. Both sexes develop orangish shading around the head and fins during spawning. Its average length is about three inches, but individuals up to seven inches (from Isle Royale in Lake Superior) have been reported.

It is found from coast to coast in North Central North America, including the Great Lakes, Upper Mississippi, Lower Hudson Bay, Upper St. Lawrence River, Mackenzie River, and Upper Rio Grande River Watersheds. It prefers turbulent water (moving more than 1.5 feet per second) over a bottom of rocks or gravel. It avoids pools and quiet areas. As a result, it is most abundant in the fast water of medium-sized streams, as well as the wave-swept shallows of the Great Lakes and large inland lakes (where waves create water movement resembling river currents). It prefers water depths of one to two feet. It can tolerate rapid changes in temperature, and tolerates temperatures up to 82° F., high turbidity, low oxygen levels, and other stressful environmental conditions. It appears to be extending its range.

The longnose dace feeds mostly on aquatic insect larvae, especially those in the Order Diptera (true flies). Algae, fine roots, sand, and gravel are sometimes also found in its stomach, probably ingested along with animal organisms. Heaviest feeding occurs in spring and fall, and it feeds sparsely from December to March. It appears to be widely preyed upon by larger fish.

It spawns from April until mid June, but most spawning occurs in May when the water warms to about 65° F. The adhesive, transparent eggs are laid among stones, and guarded by one parent. The eggs hatch in seven to ten days at a temperature of 60° F. Stream-dwelling fish spend the first four months of their lives in still, shallow water near the bank. The longnose dace reaches maturity at two years of age and can live to be five years old (females only).

The swim bladder of the longnose dace is poorly developed, an adaptation for living in the swift currents. It is sedentary and inactive in relatively quiet areas during winter. It does not seem to coexist well with sculpins. Populations can reach densities of about one fish per square yard.

Sucker Family

Worldwide, there are 60 species of sucker in 12 genera. It is believed that suckers evolved in Southeast Asia and eventually spread to North America. Today, however, there is only one remnant species found only in Asia (in China). Most species (59 in 11 genera) are from North America, with 28 species being found in the Great Lakes Watershed. Three species are known in the Chain of Lakes.

Suckers are closely related to minnows. As their name implies, their mouth is sucker-like. It is located on the lower side of the head, and can be protruded. Other distinguishing features include a short, broad head; fleshy lips (with the lower lip usually cleft); soft fin rays; a forked tail fin; an anal fin with a relatively small base (less than 2.5 times the distance from the front of the anal fin to the tip of the snout); and numerous Y-shaped bones between muscle segments. They have no teeth in their jaws, but rather grind their food against a pad using teeth at the back of their mouth.

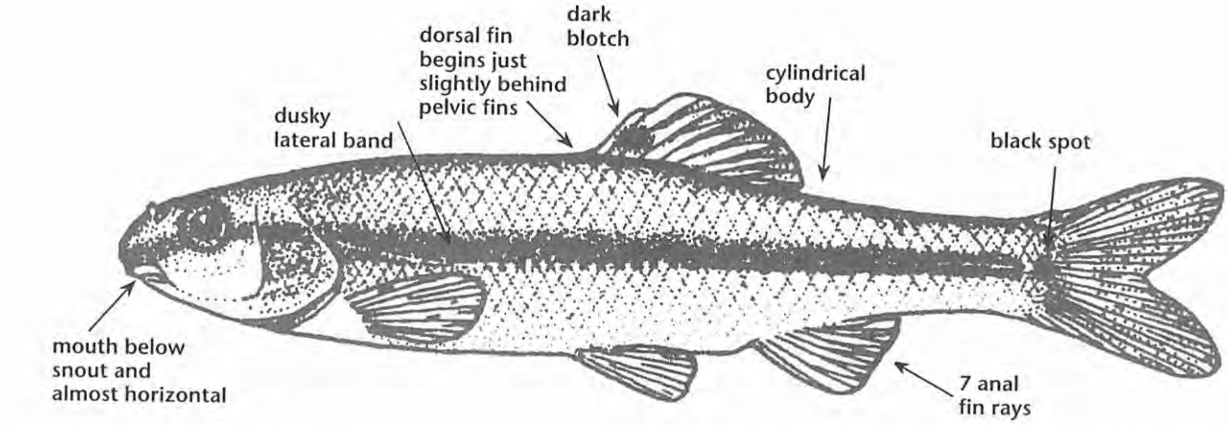
Suckers get most of their food off the bottom, finding it by touch, taste, and sight. They often have a public image as a "trash" or "rough" fish. Although their flesh is not as firm and desirable as that of most sport species, it is considered by many to be sweet and good tasting. However, the many large Y-bones between muscle segments are hard to remove and interfere with eating enjoyment.

Suckers have been widely criticized for competing with sport fish for space and food. Although the true ecological relationship of suckers and sport fishes is poorly understood, some researchers feel that its importance as a forage fish may outweigh its negative values as a competitor. Fish eggs are probably only occasionally ingested by suckers. Apparently, they do not make a special effort to seek out fish eggs for food, but merely suck them up incidentally with other food. In a study in Ontario, it was shown that predation by suckers on brook trout eggs was insignificant, compared with predation by the trout themselves. The evidence for sucker predation on the spawning grounds of more sought-after sport species is variable and inconclusive.

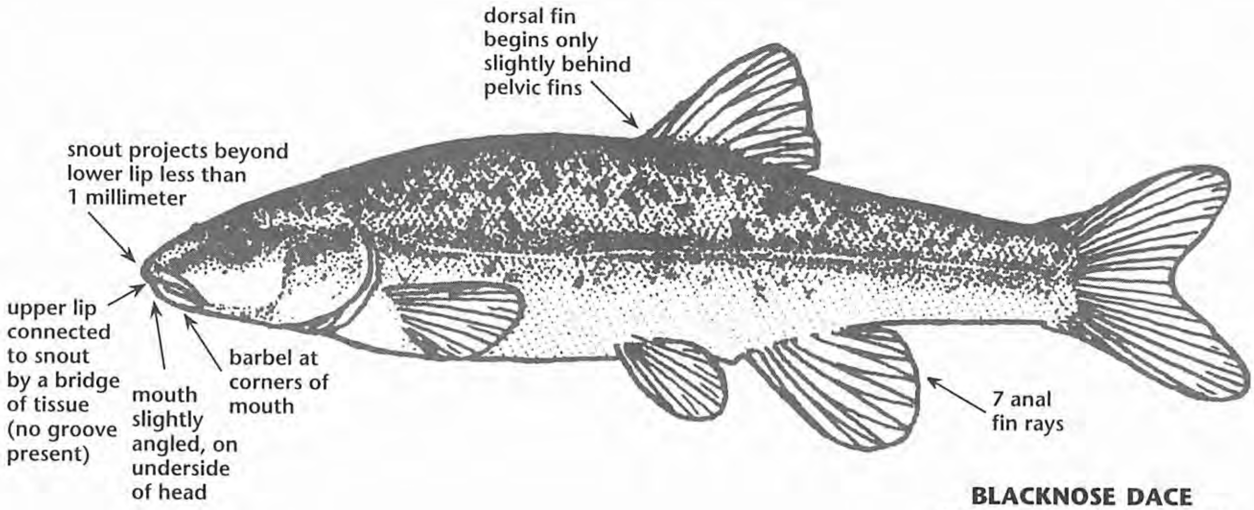
Longnose sucker *Catostomus catostomus*
(the scientific names mean inferior mouth)

The longnose sucker has a dark, slate-colored back, with lighter sides and a whitish belly. There is usually an abrupt change in color from the sides to the belly. The dorsal and tail fins are darkly pigmented, but the other fins are milky white or transparent. Young fish have three large, dark blotches on each side. Breeding males develop tubercules on the head and some fins. It has an average adult length of 16 inches. It has been known to live 19 years, and reach a length of 25 inches and a weight of 7.3 pounds.

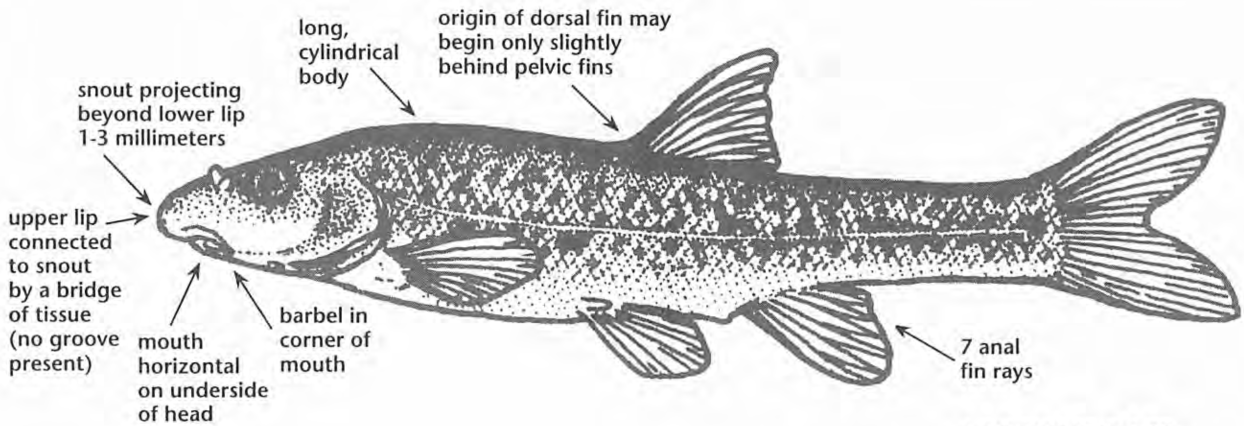
The longnose sucker is found in Northern North America, from Labrador and the Canadian Maritime Provinces, across the northern tier of the U.S. (including the St. Lawrence River, Great Lakes, Upper Missouri, and Columbia River Watersheds) and throughout Northern Canada to Alaska. It is also found in Northeast Siberia, making it the only North American sucker to be also found in Asia. It is common in the Great Lakes. In Lake Michigan,



BLUNTNOSE MINNOW
(*Pimephales notatus*)



BLACKNOSE DACE
(*Rhinichthys atratulus*)



LONGNOSE DACE
(*Rhinichthys cataractae*)

it is most abundant in the northern portion, but is uncommon in tributary streams. It is mostly found in the shallow waters of deeper lakes. It cannot stand water temperatures above 80° F.

The food of the longnose sucker includes small crustaceans, insects, and fish eggs. Young eat plankton, and have been observed grazing on weeds and solid surfaces (presumably eating associated animals).

It spawns in April and May. Spawning takes place during the day in the gravelly bottoms of streams, as well as in the shoal waters of lakes. No nest is built, and no territories are established or defended by males. Up to 35,000 pale yellow eggs are laid, a few at a time. They sink to the bottom and stick to objects they touch. Hatching takes eight to 11 days, depending on water temperature. The young remain in the gravel for one to two weeks before emerging. Those hatched in streams spend little time there before heading downstream to the lake. It matures in four years.

Longnose suckers are taken commercially in the Great Lakes (where they are grouped together with all other species of suckers). It is reported to seldom bite a baited hook.

White sucker ***Catostomus commersoni***
(the scientific names mean inferior mouth and after P. Commerson, an early French naturalist)

The white sucker has an olive to brownish back, and a light or whitish belly. Its dorsal and tail fins are lightly pigmented, and the other fins are whitish or tinged with orange. The young have three prominent dark blotches along the sides which disappear in older fish. Breeding males develop tubercules on the head, some fin areas, and the back edge of each scale; and have a pronounced dark or crimson lateral stripe. It is sometimes referred to as the common sucker. Its average length is about ten inches, but it can reach lengths of more than 20 inches and weigh more than five pounds.

The white sucker is found along the Atlantic Coast from Georgia to Labrador, west to the Rocky Mountains, and north to the sub-arctic, including the St. Lawrence River, Great Lakes, Upper Mississippi River, Lower Hudson Bay, and Mackenzie River Watersheds. It is one of the most widespread and common fish in Michigan. It is found in both streams and lakes. It can tolerate both polluted and turbid water, as well as a wide range of river current speeds and other environmental conditions. It is a bottom-dwelling fish which prefers temperatures between 53 and 65° F.

It feeds most often at night, when it moves into shallow water, but also feeds during daylight. It has a diverse diet, eating almost anything which is available, including fish, fish eggs, organic debris, plants, and mollusks. It is widely used as forage fish by other species, especially walleye, northern pike, and lake trout in some areas.

White suckers spawn from April until late May. Spawning often occurs shortly after ice-out, when the water temperature reaches 45° F. Spawning "runs" up rivers usually take place at night. Males arrive at the spawning area several days before females. No nest is built and no territory established. Spawning in rivers usually occurs in swift water over a gravelly bottom. Spawning also occurs in lakes if conditions are suitable. Two males often spawn with a single female, pressing against her from each side, vibrating rapidly and stirring up gravel and sand, arching their backs, and spreading dorsal fins wide--like a hand-held fan. No care is given to the eggs, which hatch in five to seven days, depending on water temperature. Young remain in the gravel for one to two weeks, and then move downstream to the lake over the next month. Young feed near the surface at first, but then shift to feeding on the bottom after their mouths develop better.

Young white suckers form schools of up to several hundred individuals. The average age of maturity is two years, and most are mature by four years. The white sucker has been known to live 11 years. It is an important bait fish, and is taken commercially in many areas for human and animal food. White sucker standing crops of up to 31 pounds per acre have been reported. It is the host to the larval stage of several mollusks.

Shorthead redhorse ***Moxostoma valenciennesi***
(the scientific genus name means sucking mouth)

The shorthead redhorse has a dark olive green or tan back, greenish yellow sides, and a whitish belly. Its dorsal and tail fins are reddish (pale to bright), the pectoral and pelvic fins are orangish, and the anal fin has a white edge. Its scales have dark spots at their forward bottom edge. The breeding male develops tubercules on its head, scales, and some fin rays. The average adult length is about 11 inches, but it can reach 25 inches and weigh up to ten pounds.

Its range is the Upper St. Lawrence River, Great Lakes, Lower Hudson Bay, Lake Winnipeg, and Upper Mississippi River Watersheds, as well as the Atlantic Coast from New York to South Carolina. It is found in medium to large rivers, and in large inland lakes. It is not found in the Great Lakes, except Green Bay. It is common throughout many portions of its range. In lakes, it prefers the shallows (two to 30 feet) of clear or slightly turbid waters.

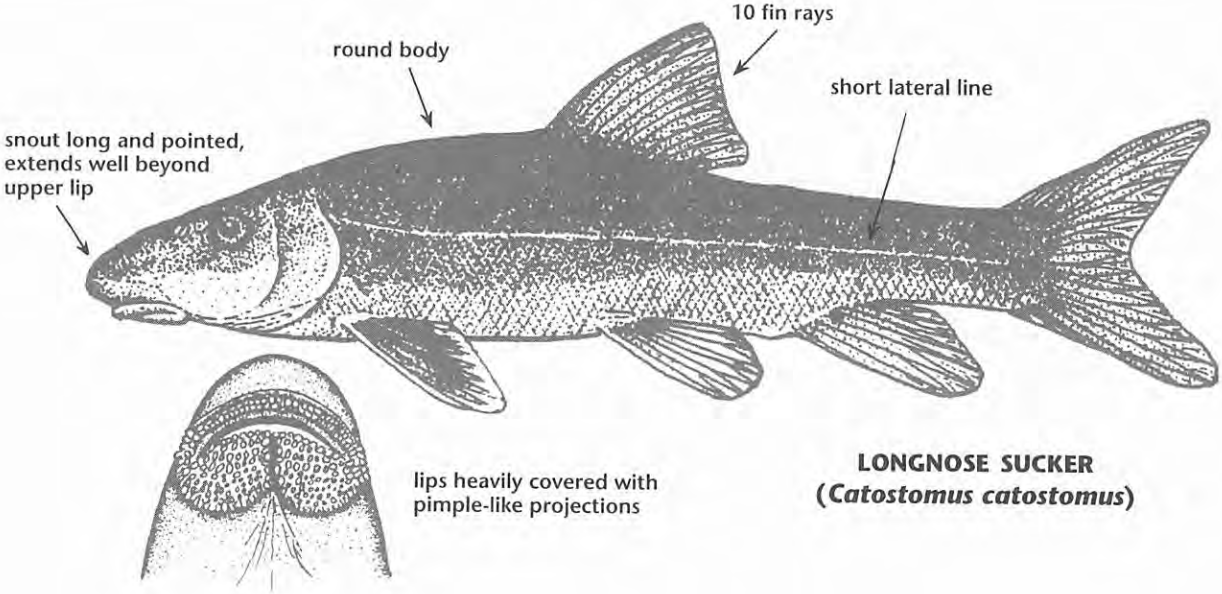
The adult shorthead redhorse appears to feed mostly on insects and mollusks. It has been observed stirring up the bottom to expose food by flicking its fins. It is reported to bite readily on a baited hook. It is often regarded as the tastiest of all the suckers.

The shorthead redhorse spawns in April and May at water temperatures between 47 and 60° F. Males arrive on the spawning grounds before females, and establish and defend territories. In rivers, spawning occurs in stony, gravelly riffles. Females can lay up to 44,000 eggs. It usually matures in its third year, and can live for 11 years.

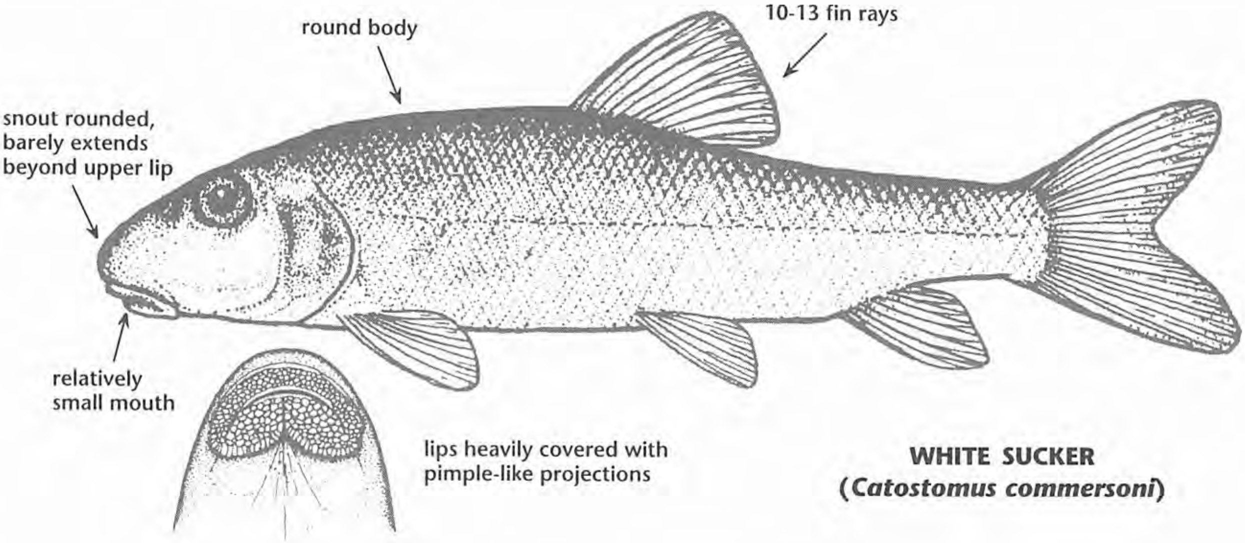
Bullhead Catfish Family

The bullhead catfish family (worldwide, there are other types of catfish in different families) originated in North America and is naturally found only in the western hemisphere. In North America, there are 39 species and five genera. Twelve species are known from the Great Lakes Watershed, and four species from the Chain of Lakes.

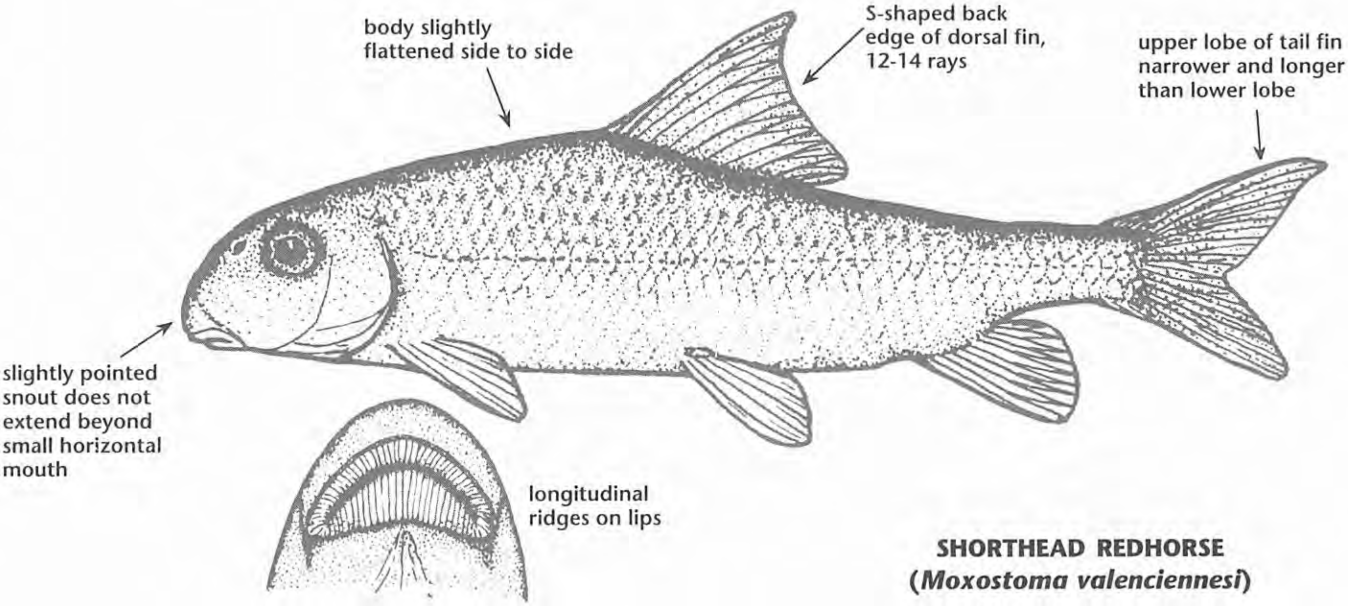
Members of the bullhead catfish family are characterized by a body which is generally rounded at the head end and flattened at the tail end; a large, flattened head; minute



LONGNOSE SUCKER
(*Catostomus catostomus*)



WHITE SUCKER
(*Catostomus commersoni*)



SHORTHEAD REDHORSE
(*Moxostoma valenciennesi*)

sharp teeth on upper and lower jaws arranged in broad pads or irregular rows; a long adipose fin; eight whisker-like barbels (reminiscent of a cat's face) containing taste buds and which are highly sensitive to touch (a pair of very long barbels sweeping back from the corner of the upper jaw, four smaller barbels on the lower chin, and a pair barbels on top of the snout); the absence of scales; and a single spiny ray in the pectoral and dorsal fins. These spines, which have an associated gland containing a mild poison, have been utilized as needles and awls by Native Americans.

When viewed from the side, the snout is bluntly pointed. When viewed from above it is broadly rounded. It has a short, but wide, horizontal mouth.

Fish in this family are generally considered to be good tasting. They are readily taken by anglers. They are hardy and able to tolerate pollutants and low oxygen levels.

Black bullhead ***Amieurus melas***

(the scientific names mean unnotched tail fin and black)

The black bullhead is olive to black on the top of its head, back, and upper sides; lighter on the lower sides; and whitish to yellowish on the belly. Its barbels are black or grey. Adults are normally seven to nine inches long, but they have been known to reach 24 inches and weigh eight pounds.

Its range is the Upper St. Lawrence River, Southern Great Lakes, Red River, and Mississippi River Watersheds, and along the Gulf Coast from Alabama to Northern Mexico. In Michigan, it is the most common member of this family. It is usually found in the shallow water of ponds, small lakes, sluggish streams, and impoundments. It is tolerant of siltation, pollutants, and warm water. It can survive temperatures up to 95° F. and oxygen levels as low as 0.2 parts per million in winter. It is frequently the only survivor when winterkill conditions develop. It seems to be expanding its range.

The black bullhead is an opportunistic feeder, eating almost anything that is available, including small fish, frogs, and carrion. It is known to be nocturnal, and as such relies on smell, taste, and touch to locate its prey. Two distinct feeding periods have been documented—just before dawn and just after dark. During the day, it usually remains inactive in weed beds. It is not preyed upon much by other fish, even when very small.

Breeding males develop a bright yellow or white belly. Spawning can occur from April through June, or later. Spawning occurs when water temperatures reach about 68° F. Females excavate saucer-shaped nests by fanning with their fins beneath matted vegetation, woody debris, overhanging banks, or even in muskrat or beaver burrows. A male and female line up head to tail, and the male arches and twists his body over hers for several seconds, at which time a gelatinous mass of yellow eggs is deposited. Eggs hatch in five to ten days, depending on temperature. Females may fan and guard the eggs initially, but eventually males take over, caring for the young for several weeks. Young black bullheads congregate in compact, swirling ball-like schools. They mature in two to four years, depending on population and food supply. Adults remain gregarious and travel in schools.

Yellow bullhead ***Amieurus natalis***

(the scientific names mean unnotched tail fin and having large buttocks)

The yellow bullhead is yellow, olive, or black on the top of head, back, and upper sides; lighter on the lower sides; and whitish to yellowish on the chin and belly. Its snout and upper jaw barbels are dark, but its chin barbels are whitish. All of its fins have dusky pigmentation. Adults are normally seven to nine inches long, but they have been known to reach 18 inches and weigh over three pounds.

Its range is Eastern and Central North America; including the Upper St. Lawrence, Southern Great Lakes, and Mississippi River Watersheds; along the Atlantic Coast from New Hampshire to Florida; and then west along the Gulf Coast from Florida to Northern Mexico. It prefers the shallow waters of clear inland lakes and medium-sized streams. It does not generally occur in the Great Lakes. It is tolerant of very low oxygen levels, but appears sensitive to some types of pollution (including detergents, which diminish its sense of taste).

Young yellow bullheads mostly eat small crustaceans and aquatic insects. Adults eat a wide variety of living and dead material, including insects, mollusks, crayfish, and minnows. However, it appears to be more selective and nocturnal in its feeding than the other bullheads present in the Chain of Lakes.

It spawns from May to July. Nests are saucer shaped depressions next to a bank, log, or tree root, often in association with aquatic plants in lakes. Females produce 2,000 to 7,000 yellowish-white adhesive eggs, but only lay 300-700 per nest. The eggs hatch in five to ten days. The parents guard the young until July or August, when they reach about two inches long. Young congregate in compact schools of several hundred until fall, when they disperse and hide under logs and stones in shallow water.

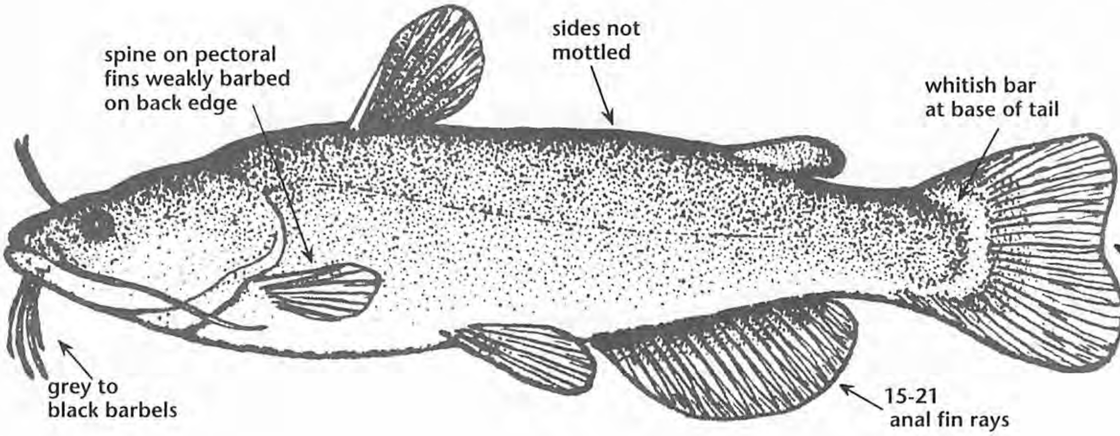
The yellow bullhead has no homing or territorial tendency. It has thinner skin than other bullheads, making it harder for anglers to clean.

Brown bullhead ***Amieurus nebulosus***

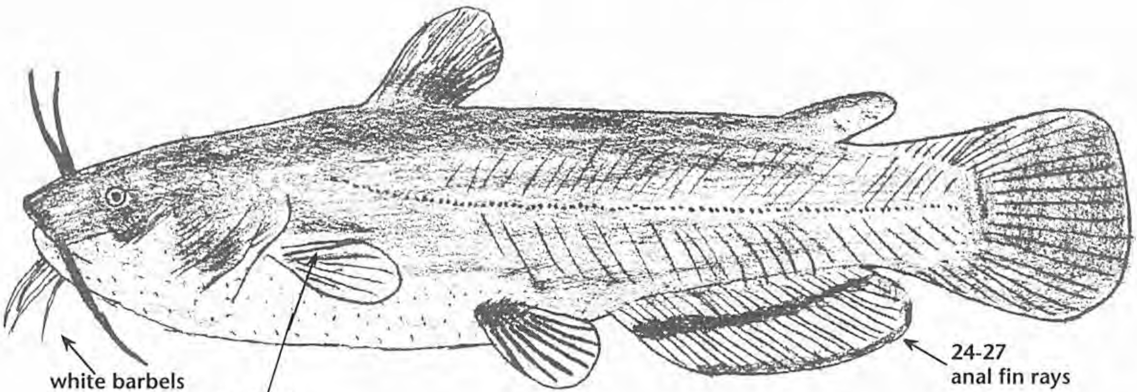
(the scientific names mean unnotched tail fin and clouded in reference to its coloring)

The brown bullhead is yellowish brown to black on top of its head, back, and upper sides. Its lower sides are mottled with lighter markings. Its chin and belly are whitish to yellowish. Its snout and upper jaw barbels are almost black, and its chin barbels are grey to black. All of its fins have dusky pigmentation. It often has reddish colored flesh. Adults are normally six to ten inches long, but they have been known to reach 21 inches and weigh over five pounds.

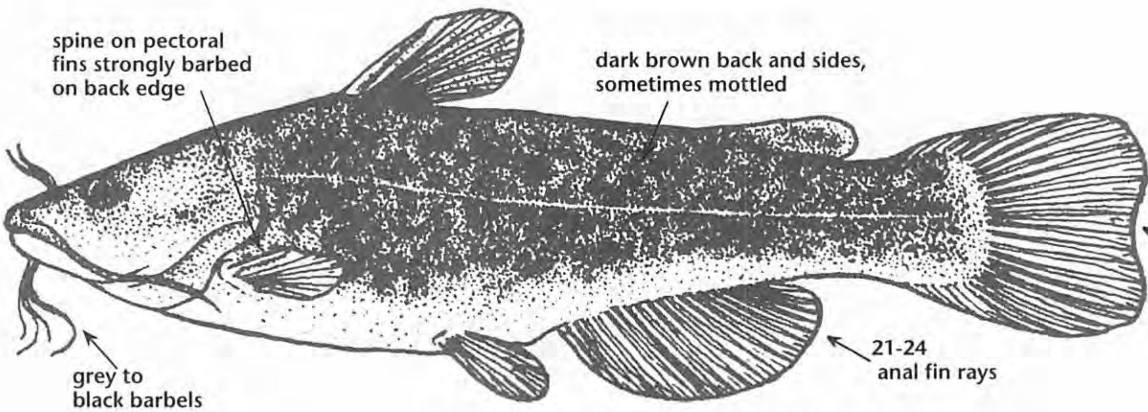
Its range is Eastern and Central North America, including the Upper St. Lawrence, Great Lakes (except Lake Superior), Red River, and Upper Mississippi River Watersheds, and along the Atlantic Coast from Nova Scotia to Florida. It inhabits weedy, shallow waters of warm water lakes and sluggish rivers. It is often found over soft bottoms where there is considerable vegetation. It appears to be the least common of the three species of bullheads in the Chain of Lakes Watershed.



BLACK BULLHEAD
(*Amieurus melas*)



YELLOW BULLHEAD
(*Amieurus natalis*)



BROWN BULLHEAD
(*Amieurus nebulosus*)

Fry and fingerlings eat zooplankton and insect larvae. Adults eat a variety of things, but frequently eat insects, fish, fish eggs, mollusks, and plants, depending upon availability.

Spawning occurs in June and July when the water warms to between 69 and 77° F. A nest is usually constructed by the female, sometimes by both sexes. The nest consists of a shallow excavation in the bottom, usually in sand or gravel near sheltering logs, rocks, or vegetation. Males drive other bullheads away from the nest site. Spawning occurs from morning until early afternoon. The spawning act is similar to that described for black bullheads. Eggs are a pale cream color and laid in an adhesive mass. A female can lay up to 3,000 eggs. Both parents seem to incubate and guard the eggs. Eggs hatch in six to nine days, depending on water temperature. The young remain on the nest for seven to ten days before swimming about. Parents "herd" the young in a tight school, sometimes capturing strays in their mouth and returning them to the school. The schools of juvenile fish stay together throughout the summer.

In fall, when water temperatures fall to about 40 to 45° F., the brown bullhead becomes sluggish and ceases feeding, often burying itself in soft organic bottom sediments with only its mouth protruding. It is chiefly nocturnal. It seems to prefer temperatures of 70° F., and has been known to survive in waters reaching 100° F. It can tolerate a wide range of water quality, including very low oxygen levels, high turbidity, and pollution. It has been observed "gulping" air at the water surface when oxygen levels become very low.

Channel catfish *Ictalurus punctatus*
(the scientific names mean fish cat and spotted)

The channel catfish is pale blue to pale olive with a silvery cast on the top half of its head and back. Its sides have various sized spots (which may disappear in older individuals). It has a whitish belly. Its long barbels are dark, and the other barbels are light colored. All of its fins are lightly pigmented. Adults are normally 12 to 20 inches long, but they have been known to reach more than 30 inches and weigh over 50 pounds.

Its range is Central and Southern North America, including the Upper St. Lawrence River, Great Lakes (except Lake Superior), Red River, and Mississippi River Watersheds; and along the Gulf Coast from Florida to Northern Mexico. It has been widely introduced elsewhere. It is common in larger rivers and connecting lake systems. It can be found in a wide variety of habitats, from clear, rocky, well-oxygenated streams to slow moving, silty rivers. It prefers warm water. In rivers, young channel catfish inhabit shallow riffles, and older fish prefer deep holes or cover such as logjams, except that they move into shallows at night. Little is known about their habits in lakes. They can stand temperatures up to 100° F., and oxygen levels down to one part per million.

Young channel catfish feed primarily on insects. Older fish eat mostly crayfish, minnows, and other small fish, as well as a wide variety of other items (snakes, birds, and beef bones have all been found in their stomachs). It usually feeds near the bottom in a random manner, detecting food by smell and touch. It has larger eyes than other members of the catfish family, and so probably relies more on sight. It is primarily nocturnal. It does not feed during winter or when spawning.

The channel catfish spawns between May and July when water temperatures reach about 75° F. It chooses a concealed area, such as an undercut bank or hollow log, for spawning. The male prepares a nest site by fanning the bottom with its fins. Females pair with males, head to tail, with tail fins wrapped around each others head. Females lay light yellow, sinking, adhesive eggs which hatch in five to ten days. Males drive the females away and guard the nest and young after spawning. The newly hatched fish remain in the nest for about a week. After that, they form schools on the bottom and eventually make forays to the surface. In the northern U.S. it generally begins maturing after four years of age. It can live for more than 15 years.

Pike Family

The pike family consists of one genus containing five species. Three of these species are found only in North America. Two species are present in the Chain of Lakes Watershed. This family probably evolved about 50 million years ago in Eurasia. Members of the pike family are all characterized by a long body somewhat flattened side to side; forked tail; dorsal and anal fins far back and opposite one another; soft-rayed fins; large head with a flat, elongated snout (like a duck's bill); large mouth with large prominent teeth on upper and lower jaws, tongue, and roof of mouth; and Y-shaped bones between muscle segments. They are all predaceous fishes and popular for sport fishing.

Northern pike *Esox lucius*
(the scientific names are after an old European word for pike, and after the Latin name for pike)

The northern pike is a variable shade of green on the back, fading to white on the belly. It has rows of light bean-shaped marks on the sides. The dorsal, anal, and tail fins have a yellow-orange tinge. Young northern pike have dark vertical bars. The average adult length is about 20 inches, but they can reach lengths of more than 40 inches and weigh up to 46 pounds.

The northern pike is distributed throughout the Earth's northern hemisphere, in fresh and even weakly brackish waters of North America, Europe, and Asia. In North America, it ranges from the St. Lawrence River, Hudson River, Great Lakes, and Upper Mississippi River Watersheds north throughout Canada and Alaska to the arctic. It prefers cool to moderately warm weedy lakes and sluggish rivers. It can tolerate a wide range of turbidity, but prefers clear to only slightly turbid waters.

Northern pike are known as voracious feeders, with cylindrical-shaped fish as its favorite prey. It captures its prey largely by sight, and as such feeds almost entirely during the day. With its shape and fin configuration, and using "jet propulsion" by rapidly ejecting water from its gills, it can accelerate incredibly quickly to ambush its prey.

Spawning occurs from late March to April, soon after the ice leaves and the water temperature reaches about 35° F. Pike migrate to spawning areas at night. Shallow (six to ten inches deep), marshy areas associated with the shoreline of a lake or stream are preferred. Pike congregate in these areas for a few days before spawning. Eventually, several males closely accompany one female, and slap her with their tails. This prompts her to lay 8,000 to 100,000 amber-colored eggs at intervals of about once per minute for an hour or so.

The eggs adhere to vegetation and hatch in 12-14 days. Water level at this time is crucial for hatching success—the proper level must be maintained for three months after eggs are laid for best survival. The newly hatched young attaches to vegetation using a sucker-type membrane on top of its head for four to 15 days while absorbing its yolk-sac. There is no parental care. Afterward, it becomes free-swimming and feeds on zooplankton. When it reaches a length of 0.75 inch, it begins eating insects. Eventually, the young pike migrate back to the main portion of the lake or river, where they begin feeding on small fish. Pike grow quickly during their fist year, attaining lengths of seven to ten inches. They become mature between one and three years of age. They usually live about seven years, but can live in the wild to be 25. In captivity, they have lived for 75 years!

The northern pike prefers a water temperature of 66° F. It can tolerate relatively low levels of oxygen, down to less than one part per million for short periods. It bites readily and is a popular sport species. As a result, it is prone to over-harvesting. One study on a Wisconsin lake showed that half of the adult pike were caught annually. They are usually present at relatively low densities of eight to 14 fish with a total weight of 15-25 pounds per acre.

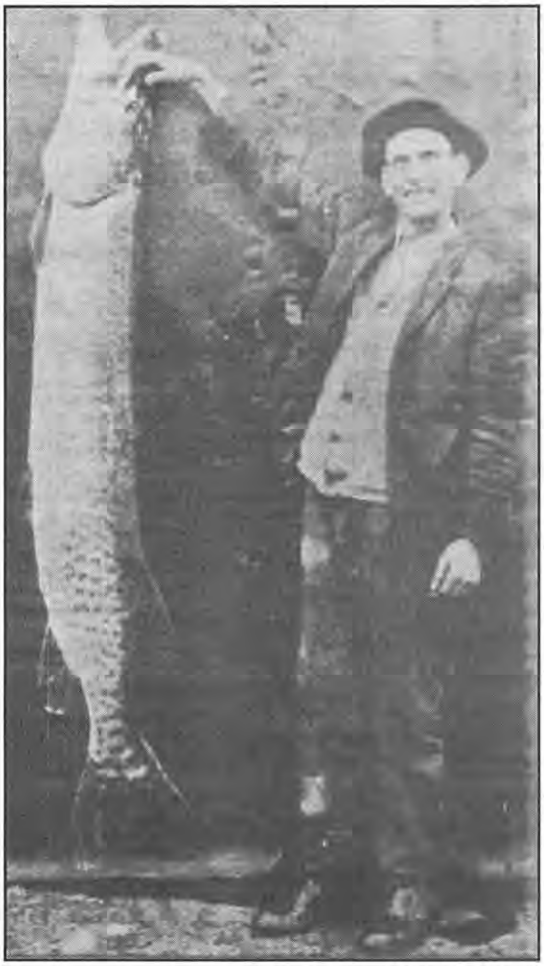


Photo courtesy *North Woods Call*

Figure 31 - Henry Rice poses with a Great Lakes musky, reportedly seven feet long and weighing 110 pounds, which he speared in the Torch River in 1930. However, its size was never verified and its authenticity is questionable. Although muskellunge over 100 pounds have been captured in nets, the current hook-and-line world record is 69 pounds, 11 ounces and was taken in Wisconsin in 1949.

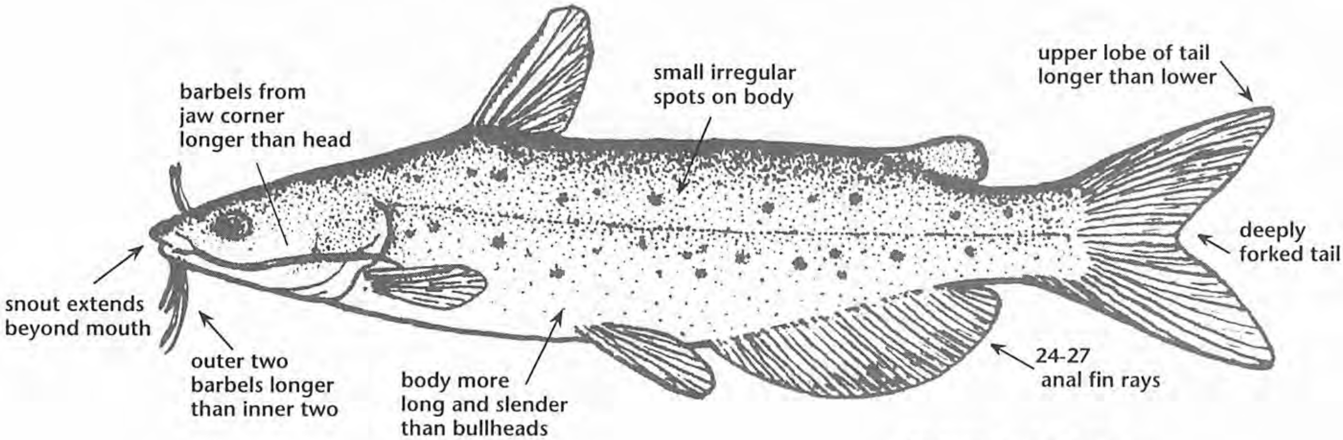
Muskellunge *Esox masquinongy*
(the scientific names are after an old European name for pike and deformed pike in Cree Indian dialect)

The muskellunge (or musky for short) has dark variable markings (such as spots, blotches, or stripes) on a silvery background on its sides. The musky naturally found in the Chain of Lakes is a variety known as the Great Lakes muskellunge (Esox masquinongy masquinongy), which is typically spotted. It has a white belly with small spots. Its fins are green to red-brown with dark blotches. Young Great Lakes muskellunge have broad, wavy green bars on their sides and a gold stripe on the top of the back. The musky's average adult length is about 30 inches, but they can reach lengths of more than 50 inches and weigh more than 100 pounds (Figure 31).

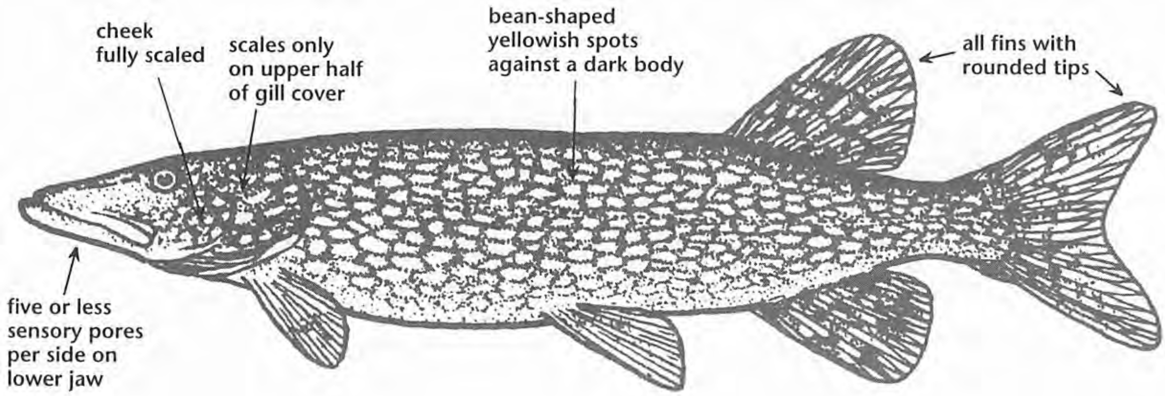
The original range of the musky is the Upper St. Lawrence River, Upper Mississippi River, Lake of the Woods, and Great Lakes Watersheds. Its range has been greatly expanded through stocking. Its habitat is pools and slower areas of medium to large rivers, and a variety of large lakes, but usually those with submerged weedbeds and extensive deep and shallow areas. It is usually found in water less than 15 feet deep, but is occasionally reported to depths of 50 feet. It prefers cool water temperatures (63° F.), but can tolerate water up to 90° F., as well as relatively low oxygen levels.

Small perch, suckers, and minnows are its preferred food, although it is occasionally known to eat small muskellunge, ducks, chipmunks, muskrats, and frogs. It is usually a lone, sedentary fish which lurks concealed among vegetation or other cover until a prey item passes within a few inches. Then, like the northern pike, it darts out with great speed, grabbing the prey in the middle, then turning it and swallowing it headfirst. It feeds largely by sight, and feeding is diminished when the water is murky. It seems to be most active in early morning, or late afternoon and evening. Some fish appear to have a specific home range or territory, and do not move widely unless food is scarce. Large Great Lakes muskellunge are nearly free from any natural predation.

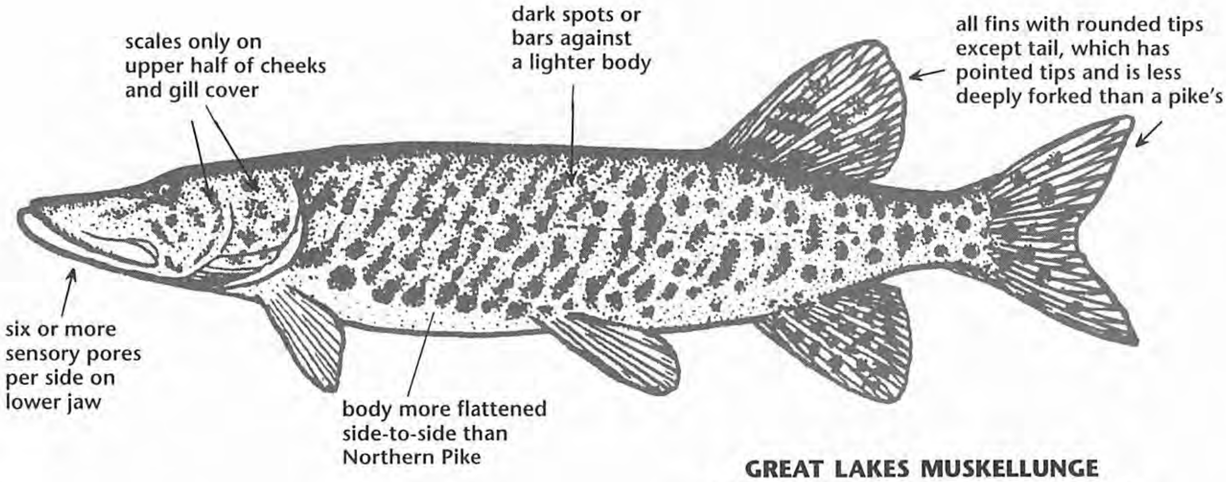
The Great Lakes muskellunge spawns from mid April to mid May, usually in shallow bays (six to 30 inches deep) with a muck bottom covered with dead vegetation. A male swims side-by-side with a female, and eggs are deposited simultaneously at intervals over several hundred yards. There is no parental care. Large females can produce up to a quarter-million eggs. The eggs hatch in eight to 14 days. The young lives off its yolk-sac for several weeks, at which time it begins freely swimming and feeding on zooplankton. After only a week or so of this, it begins feeding on small fish. The young are sensitive to temperature and water level fluctuations, and high mortality can result if conditions are



CHANNEL CATFISH
(*Ictalurus punctatus*)



NORTHERN PIKE
(*Esox lucius*)



GREAT LAKES MUSKELLUNGE
(*Esox masquinongy masquinongy*)

not perfect. It returns to the same location year after year to spawn.

Its growth for the first three to five years is rapid, but then slows. Muskellunge often attain a length of 30 inches by their fifth year. However, growth rates are highly variable between lakes. It can live for 30 years.

Northern pike and muskellunge are somewhat incompatible. Many famous musky waters have few or no pike present. Pike hatch earlier than musky, and studies show that pike fry will prey on musky fry. Where they do occur together, northern pike and muskellunge can form a natural (but sterile) hybrid called a tiger muskellunge. This hybrid is cultivated in hatcheries and widely planted. The muskellunge is a spectacular fighter, and is one of the most famous and sought after trophy fish in North America.

Mudminnow Family

The mudminnow family evolved about 50 million years ago in Europe. It consists of five species in three genera worldwide. The central mudminnow is the only species in the Great Lakes Watershed.

Mudminnows are small fishes with rounded tail fins, short snouts, and flattened heads. They have fan-like pectoral fins (which may be either large or small); small pelvic fins set back near the anal fin; small, slender, closely-set teeth; relatively large sacles; and no lateral line.

Central mudminnow *Umbra Limi*

(the scientific names mean shade or dark and mud)

The central mudminnow has mottled dark-greenish brown sides with up to 14 dark vertical bars (which may be indistinct), and a yellow to white belly. Its fins are brownish. It is the only fish in the region with a dark vertical bar at the base of a rounded tail fin. Its average length is about 2.5 inches, but it can reach a length of 5.5 inches.

It is found in Central North America, including the Upper St. Lawrence, Great Lakes (except Lake Superior), Upper Mississippi, and Lake Winnipeg Watersheds. It is common to abundant in marshes; ditches; bog lakes; and small, slow streams. It prefers clear waters several feet deep with abundant vegetation. As its name implies, it prefers soft-bottomed habitats.

The central mudminnow is mainly a bottom feeder, eating small snails, crustaceans, and insects. It is a slow swimmer and lies concealed in mud or vegetation much of the time. It is easily disturbed, diving under the mud or other cover for concealment. For these reasons, and because it does not normally inhabit the same areas as sport fish, it is not often observed by anglers.

Mudminnows spawn in the spring when the water temperature reaches 55-60° F. Flooded areas are its preferred spawning sites. Females deposit up to 450 yellow or orange adhesive eggs singly on the leaves of plants. The eggs hatch into transparent fry in about six days. In several months, when they are about an inch long, the fry move into the main water body. Mudminnows can live to be nine years old.

It is a very hardy fish. It has the ability to gulp surface air (or air bubbles under the ice) when oxygen levels get very low. It can reportedly survive superficial freezing and often survives when fish poisons are intentionally applied for management purposes. It can survive water temperatures up to 100° F. It is preyed upon by other fish and birds. It makes an attractive and interesting aquarium pet. It is often used for bait.

Smelt Family

There are ten species in six genera worldwide in the smelt family, all found in northern areas of the northern hemisphere. They mostly live in salt water, sometimes ascending rivers to spawn. In North America, there are nine species in six genera. Smelt are all small, slender, silvery fishes with large, well-toothed mouths; thin, round scales; soft-rayed fins, and an adipose fin.

Rainbow smelt *Osmerus mordax*

(the scientific names mean odorous and biting)

The rainbow smelt is a small (average length of seven inches), slender, silvery fish, with blue shading on the back and a white belly. Some large specimens have a faint lateral stripe. The fins are generally unpigmented.

The rainbow smelt is a salt-water species which ascends freshwater streams to spawn. It was originally found along the Northeast Atlantic Coast of North America, along the Arctic and Pacific Ocean Coasts from the Central Canadian Arctic to Vancouver Island, as well as northern coastal waters of Europe and Asia. It was planted in Crystal Lake, Michigan in 1912, and has since spread to all the Great Lakes and many inland waters. It generally inhabits water 60 to 80 feet deep in the Great Lakes. Its preferred temperature is 50° F. It can compete with, or displace, native coldwater species such as cisco and whitefish.

The rainbow smelt preys on large crustacean zooplankton or small fish, including its own young. It can be either an open-water or bottom-dwelling species. It is a preferred prey item for lake trout and other predator species. It is often caught on hook and line using small minnows (primarily in the winter and at night), and during its spawning runs using dip nets (where allowed). Many people consider it to be delectable eating.

It spawns during a two week period from late March to early May, when the water temperature reaches 40° F. Most spawning occurs near the mouth of tributary streams. It is also known to spawn in shallow gravelly areas near lakeshores. Spawning takes place principally at night. Several males take up a position above a female and drive her to the bottom, where she releases up to 50 eggs at a time. Eggs sink to the bottom and become attached to the gravel by a short stalk. The eggs hatch in 10 to 30 days, depending on temperature. In streams, the fry are carried downstream after hatching. They mature in one to three years.

Trout Family

It is generally believed that the trout family contains 39 species in seven genera in North America, however, experts disagree on the total number of species. There are 19 species in five genera in the Great Lakes Watershed.

Members of the trout family are generally medium- to large-sized fishes with cylindrical or slightly flattened bodies tapering (like a football) at both ends. They all have adipose fins; soft fin rays; and thin, round scales on their body (the head being scaleless).

They are the dominant family of fish in the northern waters of North America, Europe, and Asia. They all require low water temperatures. They either live in freshwater or, if found in salt water, ascend rivers to spawn. It is an economically important family for both sport and commercial fishing. The trout family has been divided into three sub-families.

1. The whitefish sub-family is characterized by having 15 or fewer dorsal fin rays, relatively large scales (less than 100 along the lateral line), small mouths with no teeth on weak jaws, small eggs, and young without parr marks (broad vertical dark bars on the sides). Identification of the species in this sub-family has been called the most perplexing of all the North American fishes.
2. The trout sub-family is characterized by having 16 or fewer dorsal fin rays, small rounded scales (more than 100 along the lateral line), large mouths with well-developed teeth, large eggs, and young with parr marks. Their bodies are more flattened side to side than fish in the other sub-families. There are two native species in the Great Lakes Watershed, but many species have been introduced over the years (although not all of the introductions have taken hold). Members of this sub-family are highly migratory.
3. The grayling sub-family is characterized by having 17 or more rays on a large dorsal fin, large scales, and small eggs.

Lake herring or cisco *Coregonus artedi*
(the scientific names mean angle-eye and after Petrus Artedi, the "father of Ichthyology" and a protege of the famous biologist Linneaus)

The lake herring has a silvery color with a blueish to greyish back. Its average length is about 11 inches, but its size varies greatly from lake to lake. It has been known to live for 11 years and reach a weight of eight pounds.

It is found in the North Central U.S. and most of Canada, but principally in the Upper St. Lawrence, Great Lakes, Upper Mississippi, Hudson Bay, and Arctic Ocean watersheds east of the Rocky Mountains. It inhabits the relatively shallow waters (60-100 feet) of the Great Lakes and deep (generally deeper than 35 feet), infertile inland lakes. It is now declining or rare in most of the Great Lakes, but is still abundant in many inland lakes. It prefers water temperatures below 64° F. and requires oxygen levels above three to four parts per million.

The lake herring is primarily an open-water feeder, filtering crustacean plankton out of the water with structures called gill rakers. However, larger lake herring also eat mollusks, insects, and small fish. It is a fish which seems to be constantly on the move. Late summer can be a critical period for lake herring. In some lakes a summerkill can occur when cold, oxygen-rich waters disappear.

Spawning occurs in the fall from early November to mid December, usually when the water temperature is about 38 to 42° F. Spawning occurs in water three to six feet deep on a bottom free of vegetation. Spawning begins with several males following a single female. The female descends close to the bottom, where she releases eggs and the males release sperm. A female may release from 4,000 to 10,000 eggs. The eggs are scattered over the bottom where they adhere to rocks or other objects. Open-water (with fish splashing at the surface over deeper water) and stream spawning has also been observed. Spawning generally occurs at night. The eggs hatch in late April or early May. After hatching, the fry remain in the shallows for about a month before moving into deeper water. It reaches maturity during its second or third year.

Lake whitefish *Coregonus clupeaformis*
(the scientific names mean angle-eye and herring-shaped)

The lake whitefish is generally silvery. Its back has a pale greenish cast, its sides are silvery-blueish white, and its belly is whitish. The average length is 18 inches and four pounds, but it has been known to reach more than 20 pounds.

It is found throughout Canada from the Atlantic to the Pacific and north to the Arctic Ocean, and in the Great Lakes Watershed and the Northeast U.S. It is found in all the Great Lakes and in large, deep inland lakes. It is considered a shallow water member of the whitefish sub-family, usually not being found deeper than 100 feet.

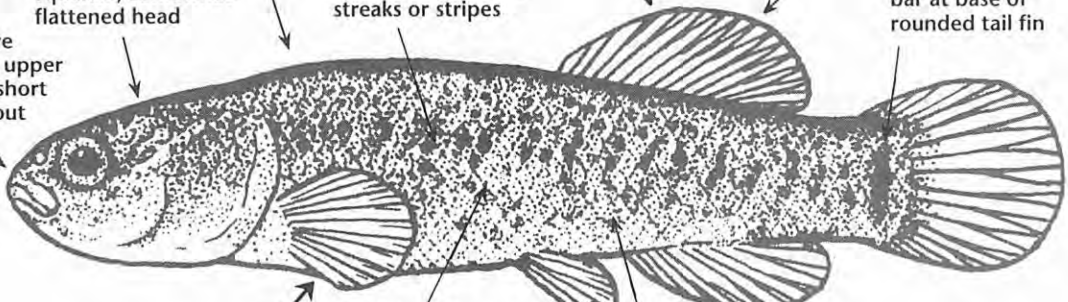
Spawning occurs in the fall between late October and early December, when the water temperature reaches about 42° F. Spawning usually occurs at night over gravel or small rocks in six to 50 feet of water. Females accompanied by several males rise to the surface (sometimes jumping) where they release 25,000 to 130,000 orange-yellow eggs. The eggs settle to the bottom, and there is no parental care. The eggs hatch about 130 days later, in late March or early April.

The young inhabit relatively shallow water until summer, primarily eating crustacean zooplankton. After that they migrate to deeper water and begin feeding on bottom dwelling invertebrates. Whitefish congregate in schools. There is evidence that schools remain in a relatively small home range, and do not wander greatly. It is considered by many to have the finest flavor of any Michigan fish, and is an important commercial species in the Great Lakes.

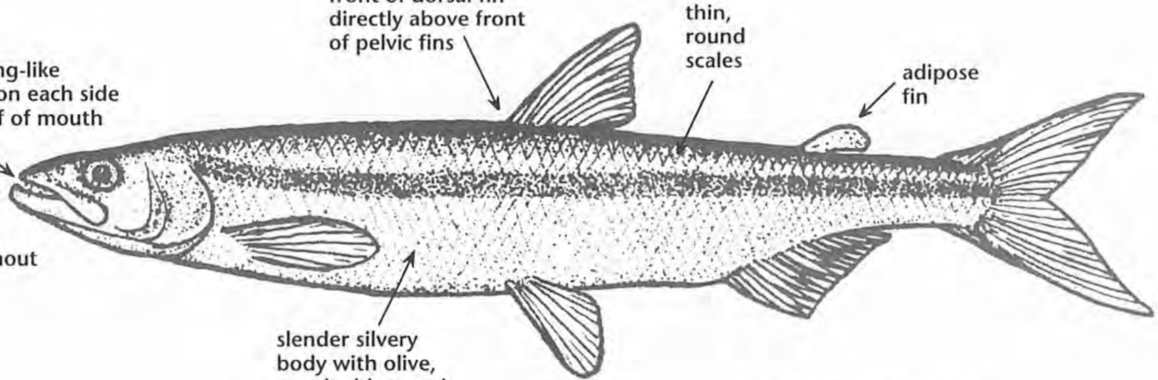
Rainbow trout *Onchorynchus mykiss*
(the scientific names mean hooked mouth and the name of this species in Asia)

The rainbow trout has a silvery blue-green back and upper sides, silvery to grey sides with a broad pinkish stripe, and whitish underparts. There are many dark spots, mostly above the lateral line. The dorsal and tail fins have rows of dark spots, and the olive green adipose fin has a black border and a few spots. In large lakes, the fish may have a more silvery blue color and lack the pink stripe and spots on the sides (these fish are often migratory and are sometimes called steelhead). Young have five to ten dark oval parr marks. Males develop a hooked lower jaw during spawning.

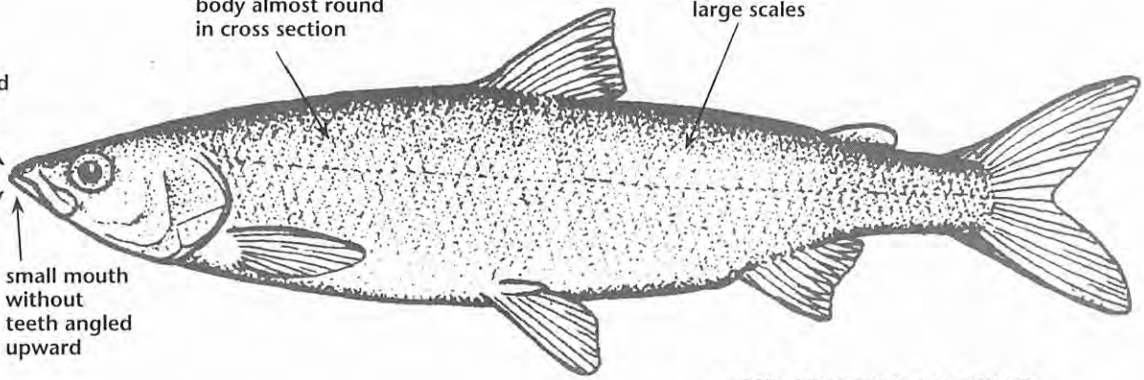
Average size in the Great Lakes is 26 inches and about 7.5 pounds. However, in small inland lakes and streams



CENTRAL MUDMINNOW
(*Umbra limi*)



RAINBOW SMELT
(*Osmerus mordax*)



LAKE HERRING OR CISCO
(*Coregonus artedi*)

adults are often much smaller, sometimes not even reaching eight inches. Rainbow trout sometimes reach weights of 25 pounds or more.

The rainbow trout was originally found in waters of the Pacific coast from Northwest Mexico to Western Alaska and inland freshwaters west of the Rocky Mountains. However, it has been widely introduced to suitable habitats throughout the U.S., Southern Canada, and the rest of the world. Rainbow trout were introduced to the Upper Great Lakes Watershed in the late 1800's.

It prefers rapid stretches of cool streams, but survives well in deep inland lakes. It tolerates higher water temperatures than any other trout. It eats a wide variety of food, including immature and adult aquatic insects, terrestrial insects, and fish.

Spawning occurs in streams in spring, usually late March through early May. Spawning occurs during daylight hours. Females construct the nest by excavating a depression in the gravel bottom using their fins and body. Several males may pair with one female. Both defend the nest against intruders. In areas of limited spawning habitat, nests may be in close proximity to each other. Eggs hatch in two to three weeks. The fry remain in the gravel for another two to three weeks, after which they emerge and begin swimming freely and feeding. The rainbow trout grows slowly through its first two years of life. The young spend several years in the spawning stream, and then migrate downstream to a large lake (or the ocean in their original range) when they are 6.5 to 10 inches long. They can live up to 11 years, but few live more than six years.

Kokanee salmon *Onchorynchus nerka*

(the scientific names mean hooked mouth and after the Russian name for the migratory saltwater sockeye salmon)

The top half of the kokanee salmon's body is steel-blue or green-blue with no distinct black spots, and the sides are silvery. The dorsal fin has a few dark marks, but the other fins are clear. It usually only reaches a length of eight to 15 inches when mature, but fish up to eight pounds have been reported.

The kokanee salmon is a freshwater form of the Pacific Ocean's sockeye salmon. It is naturally found in inland lakes located close to the range of the sockeye salmon, which is along the Pacific coast from Northern California to Northern Alaska, as well as the North Pacific and Arctic Ocean Coasts of Asia. However, it has been planted widely in distant locations, including the Great Lakes and Torch Lake (in 1965 and 1966). It never became naturalized in Torch Lake, and none are present today.

It prefers a temperature of 50-59° F. It mainly feeds on zooplankton suspended in open water areas, but it is also known to eat insects and bottom organisms. Sport anglers can catch it using flashy artificial lures, as well as baits like salmon eggs, worms, and flies.

Like other salmon, it spawns in the fall, generally during September and October. Spawning takes place in tributary streams, or along gravelly lake shores, in water one to 30 feet deep. The female prepares the nest in pea-sized gravel by lying on her side and beating her tail up and down. The male and female swim into the nest, mouths agape, and simultaneously deposit eggs and sperm. The eggs are covered with gravel by the female. Eggs hatch in 48-140 days, depending on water temperature. It lives four years. Both adults usually die within several weeks of spawning.

Atlantic salmon *Salmo salar*

(the scientific names mean salmon of the Atlantic and leap)

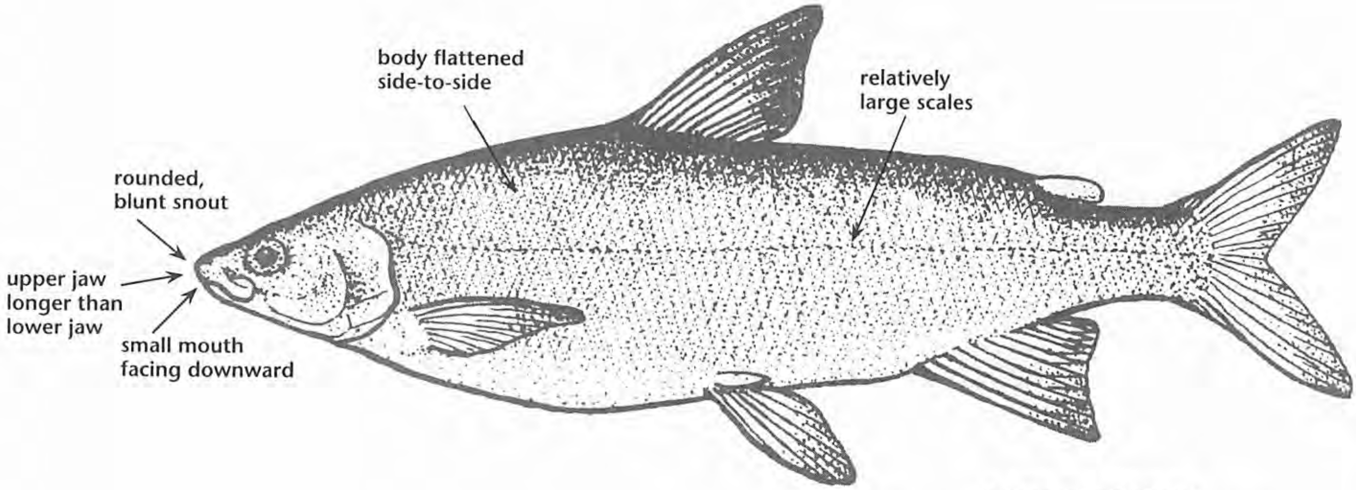
The Atlantic salmon is native to the North Atlantic and Arctic Oceans, from Northern Russia to Portugal in Europe, Iceland, Southern Greenland, from Labrador to Connecticut in North America, along the St. Lawrence River, and in Lake Ontario (but the population there was extirpated in the late 1800's). A landlocked form (called landlocked salmon) is found in inland lakes near the coast throughout this region. It has been introduced into many inland lakes throughout North America, but few have resulted in self-sustaining populations. It has been planted off and on in Torch Lake since 1882.

Lake or sea-dwelling adult Atlantic salmon are brown, green, or blue on the back, silvery on the sides, and silvery white on the bottom. However, it develops a darker bronze or brown color upon entering streams during spawning. The young have eight to 11 narrow, pigmented parr marks with a single red spot between each along the lateral line on each side. Its average length is about 18 inches, but sea-run fish have been known to attain weights of 80 pounds. Landlocked salmon in New England average about two to four pounds, but specimens up to 35 pounds have been recorded.

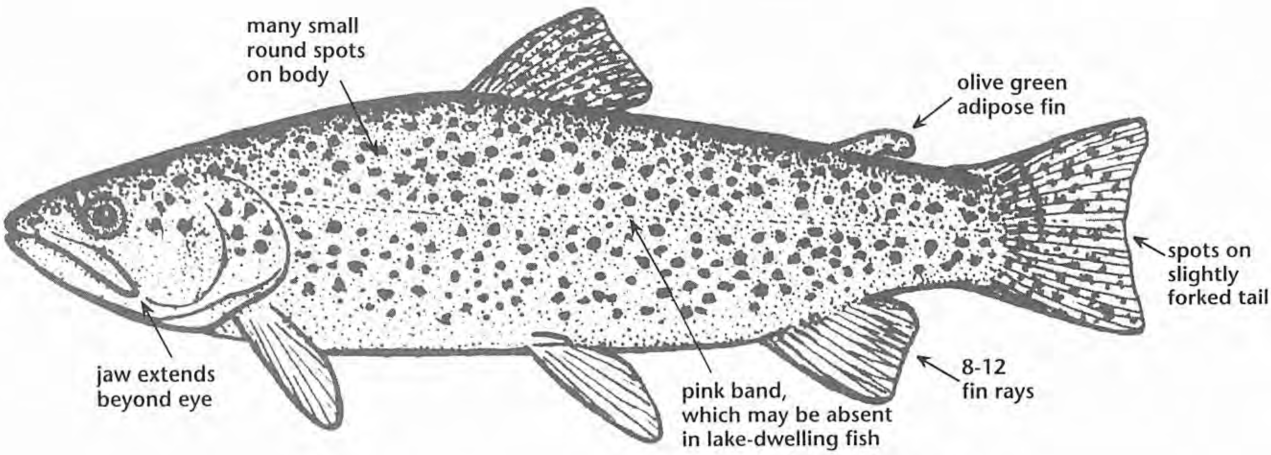
Young Atlantic salmon eat mainly insects and other stream invertebrates. In lakes, it mostly eats fish. Despite its willingness to take fishing lures, it does not feed during spawning.

Beginning in late summer, it moves to the mouth of cold gravel-bottomed spawning streams, but actual spawning takes place in October and November. The nesting site, usually in a gravel-bottomed riffle above or below a pool, is chosen by the female. Turning on her side, she uses her tail fin like a paddle to excavate a depression. After excavation, a male aligns himself alongside her, and eggs and sperm are released. Males drive off other salmon from the nest area. The female covers the eggs with gravel afterward. This behavior is repeated many times during spawning. Eggs are large (about 0.25 inch diameter) and somewhat adhesive for a short time. Females release about 700 eggs per pound of body weight. Unlike Pacific salmon, Atlantic salmon do not always die after spawning, and survivors return to the lake or sea. The eggs hatch in about 110 days, depending on temperature (usually in April). The young remain buried in the gravel until the yolk sack is absorbed, usually a month or so.

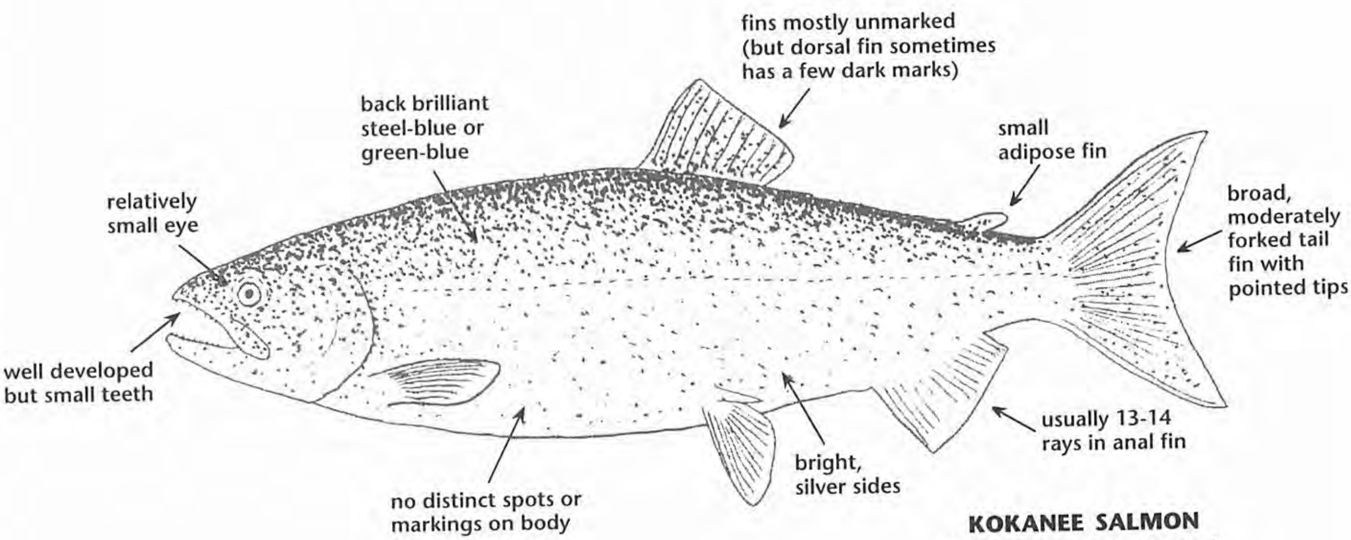
The young remain in the stream for two to three years, when they are about five to seven inches long. Then, they descend to the lake or sea where they spend one or more years before returning to the river to spawn. The adult ocean-dwelling Atlantic salmon probably ranges widely, but its habits there are not well known. In lakes, it remains in the upper layer while the water is cool (fall-spring), but



LAKE WHITEFISH
(*Coregonus clupeaformis*)



RAINBOW TROUT
(*Onchorynchus mykiss*)



KOKANEE SALMON
(*Oncorhynchus nerka*)

migrates to greater depths in summer as the water warms. It has been prized and revered for centuries, but unfortunately it has been decimated in North America by dams, pollution, and over fishing.

Brown trout *Salmo trutta*
(the scientific names mean salmon of the Atlantic and after a Latin word for trout)

The brown trout typically has an olive brown back fading to a lighter brown on the sides, and a white belly. The dorsal fin, back, and sides have large dark spots with a lighter "halo." There are few or no spots on the tail fin. The adipose fin is orangish. In large lakes, it may have a more silvery-grey coloring. Young have seven to ten distinct pale round spots along the lateral line, and dark speckles on the abdomen and chin. Males develop a hooked lower jaw during spawning. Its average adult size in large lakes is about 18 inches, with a weight of several pounds. However, in small inland lakes and streams it is often much smaller. Brown trout sometimes reach weights of almost 40 pounds.

The brown trout is native to Europe and Western Asia, including Iceland and the British Isles. It was introduced to North America in 1883, and is now widely present and naturally reproducing in suitable habitats throughout southern Canada, the U.S., and the rest of the world. It is common in coldwater streams. It tolerates higher temperature (preferred temperature is 53-64° F., and the upper lethal temperature is 78° F.) and more turbidity than brook trout. It is also found in the Great Lakes where it inhabits relatively shallow water (less than 50 feet deep), and in large deep inland lakes.

In lakes, young brown trout eat mostly invertebrates and zooplankton; and larger, older brown trout primarily eat fish. In streams, small fish and aquatic insects are its mainstay. It is a secretive fish in streams, and is most active during the evening, at night, and early in the morning. Brown trout are aggressive and have contributed to the decline of brook trout, especially where habitat conditions are marginal for brook trout.

Spawning occurs in the fall from October to December. A saucer-shaped nest is excavated in gravel riffles by the female (although the presence of a male is necessary to stimulate the female to do so). Where gravel is absent, brown trout have been known to utilize hard clay or sand bottoms for spawning. Females lay between 400 and 7,500 eggs, depending on size. The eggs are covered by gravel after being deposited, and hatch in about 50 days. It grows rapidly, and may mature in about 20 months. It can live for 18 years or more. The young of brown trout which live in lakes but spawn in streams spend about two years in the stream before migrating to the lake to live as an adult.

Brook trout *Salvelinus fontinalis*
(the scientific names mean an old name for char and living in springs)

The brook trout is olive, blue-grey, or black with wormlike markings on its back. Its sides have red spots sometimes surrounded by blueish halos. Its belly is white. The fins on the lower body are reddish with black and white stripes along the front edges. Fish which live in large lakes take on a silvery appearance. A variety of large brook trout living in the Great Lakes but ascending tributaries to spawn are known as "coaster" brook trout. Breeding males develop orange-red bellies with darkened sides, and a hooked lower jaw. The young have seven to nine large brown parr marks along the lateral line. Its average size in inland streams is six to eight inches, but brook trout can reach lengths greater than 20 inches and weigh up to 14 pounds.

The brook trout is native to Northeastern North America: along the Atlantic Coast from Labrador to Cape Cod, in the Applachian Mountains south to Georgia, and the St. Lawrence River, Upper Mississippi River, Great Lakes, and Hudson Bay Watersheds. It is the only stream-dwelling member of the trout family native to Michigan which is still present.

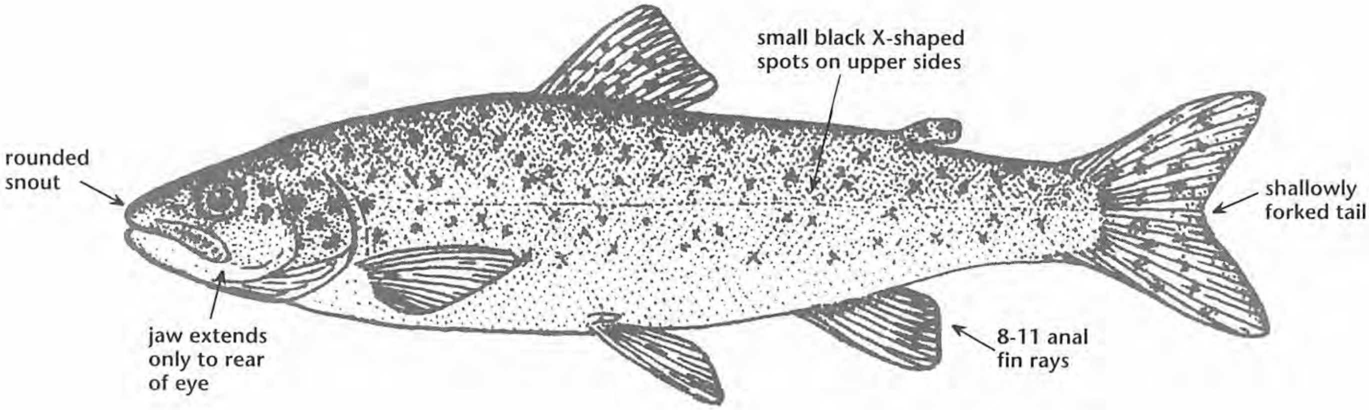
It usually inhabits cool, clear, spring-fed headwater streams and ponds. Its preferred temperature is 57-60° F., with an upper lethal limit of 77° F. It cannot tolerate low oxygen, siltation, or many other types of pollutants. In streams, it often lies in deep pools or under cover of logs, vegetation, or overhanging banks. It is a voracious feeder, consuming large quantities of insects and other aquatic invertebrates, worms, and small fish. It may congregate in groups, but is not a schooling fish. It is considered to be the most easily caught of all Michigan trout. Fish commonly associated with brook trout include mottled sculpin, brook stickleback, creek chub, and pearl dace. It has been stocked successfully in deep lakes which maintain cold, well-oxygenated water during summer.

Spawning occurs in fall, usually about mid November. It spawns in gravelly riffles in streams or in upwelling spring seepage areas in lakes and ponds. The female constructs a nest (one to two feet in diameter and an inch or so deep) by turning on her side and vibrating her body and tail against the bottom. She works at nest construction day and night for several days. A nearby male fends off intruders. The female takes a position in the bottom of the nest and a male positions himself against her side, holding her to the bottom and vibrating rapidly. Eggs and sperm are released simultaneously. Female brook trout lay 100 to 1,000 relatively large eggs, depending on body size. When all her eggs are laid, she covers the eggs with gravel. Eggs hatch in 50 to 150 days, depending on temperature. The fry remain under the gravel until their yolk sac is absorbed. Growth is variable, depending on food and habitat. A few brook trout become mature at the end of their first year. Few live longer than six years, and most only about three.

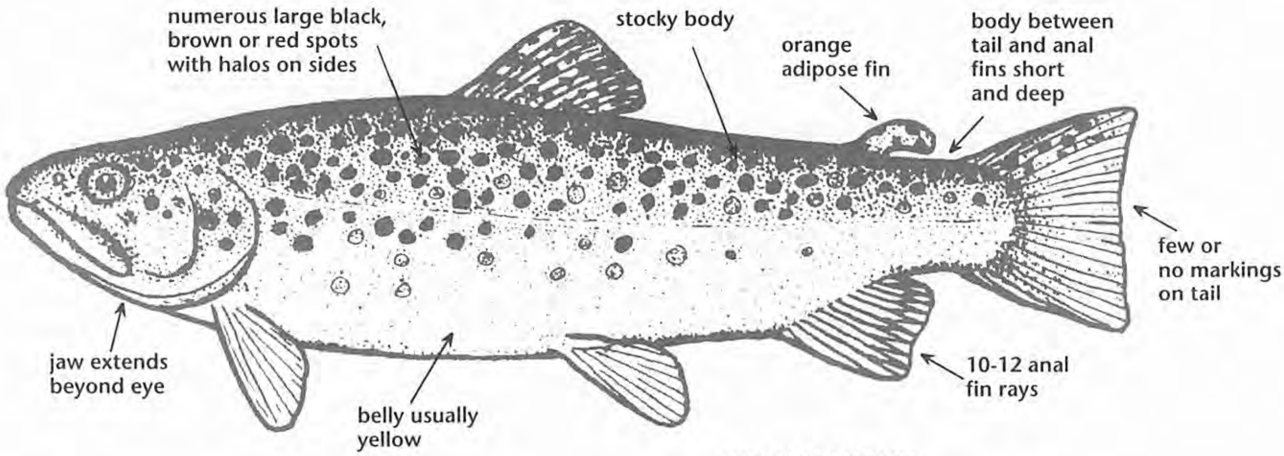
Lake trout *Salvelinus namaycush*
(the scientific names are an old name for char and a native American name for this species [dialect unknown].)

The back, sides, and head of the lake trout are light green or grey with light spots. It has a white belly and the lower fins usually have a white leading edge. Lake trout are the largest of all trout. The largest specimen known (caught commercially in Canada) weighed 102 pounds, but the average size is 15 to 20 inches and weighs several pounds.

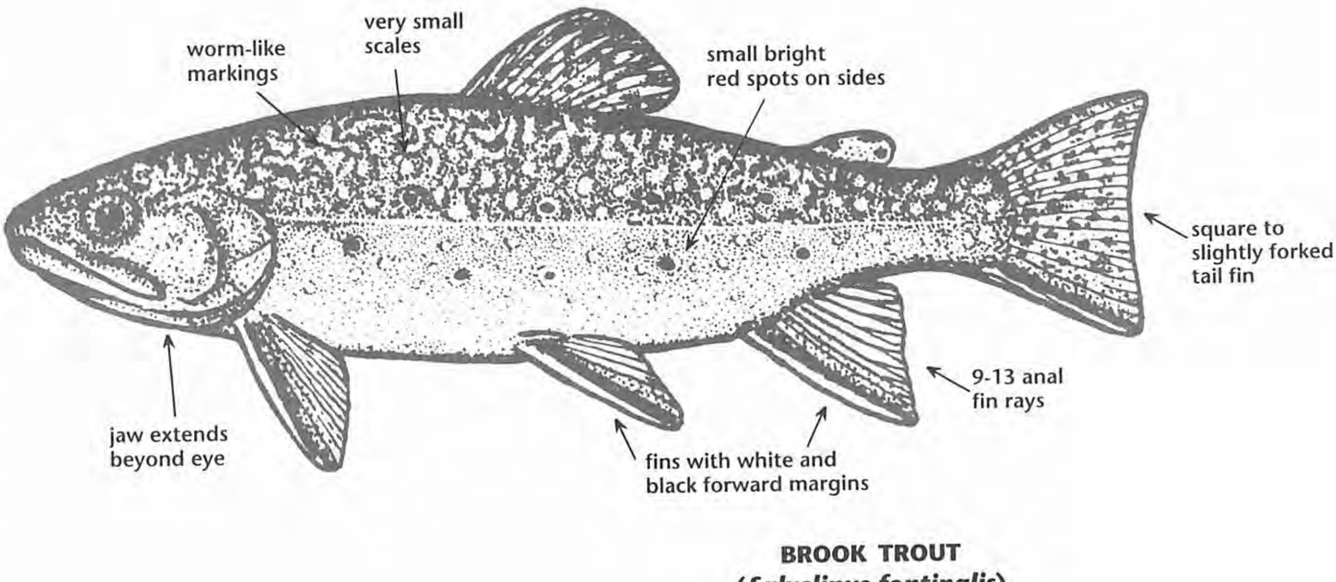
The lake trout is found throughout the northern



ATLANTIC SALMON
(*Salmo salar*)



BROWN TROUT
(*Salmo trutta*)



BROOK TROUT
(*Salvelinus fontinalis*)

portions of North America, generally from the Great Lakes north. In the Chain of Lakes, it apparently originally occurred naturally in Bellaire, Elk, and Torch Lakes, although naturally reproducing populations are now limited to Elk and Torch. Lake trout spend most of their lives in cold, deep lake waters. It generally lives at or near the bottom, but may also be suspended in the water column. Its preferred water temperature is 51° F.

Opossum shrimp (Mysis relicta) and deepwater sideswimmers (Diporeia hoyi), small crustaceans found only in the deep waters of low-productivity lakes like Torch and Elk, are the most important food of young lake trout (Figure 32). Older fish primarily eat other fish, such as cisco, sculpin, smelt, or probably whatever fish happens to be available. However, adults are also known to eat invertebrates and zooplankton. It does not school, but congregations may sometimes form. Lake trout are found in association with cisco, whitefish, deepwater sculpin, and burbot. It is a popular sport fish and well regarded for eating.

Spawning occurs in fall on silt-free rocky bars from very shallow water to depths of 100 feet, when the water temperature cools to 46-52° F. No nest is built, but males clean the bottom of debris. Most spawning occurs at night. Fish are polygamous and spawn in groups. There is no territoriality and little fighting. Males nip the females and press against their sides to stimulate egg laying. Eggs sink into crevices of rocks, and there is no care of eggs or young. The eggs take four to five months to hatch. The fish return to the same spawning grounds each year. Lake trout mature in four to seven years, usually when they are about 24 inches long. In some regions, lake trout are known to spawn in rivers, and river-run strains from Lake Michigan may have utilized some streams of the Elk River Watershed for spawning before being killed-off by dams and over-fishing. Mudpuppies (aquatic salamanders) are known to eat lake trout eggs.

The lake trout will occasionally naturally mate with a brook trout, creating a sterile hybrid called a splake. Splake are relatively easy to culture, and they have been raised in hatcheries and planted widely.

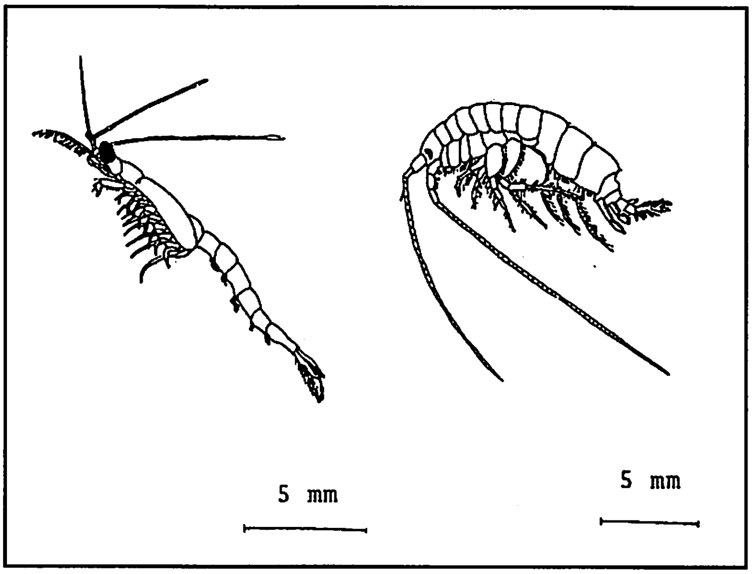


Figure 32 - Opossum shrimp (L) and deepwater sideswimmer (R).

Arctic grayling *Thymallus arcticus*

(the scientific names mean thyme-like, referring to its supposed odor, and of the arctic)

The color of the arctic grayling is dark purple to blue-black on the back, grey to dark blue on the sides with pinkish iridescence and V- or diamond-shaped spots, and grey to white on the belly. The dorsal fin is vividly colored (dark greenish black with a mauve edge, blue band, and reddish and greenish spots), and it has a gold eye. Its young have deeper bodies than most other members of the trout family, and 10-20 parr marks. The average length is 12-15 inches but they can reach almost 30 inches and weigh more than six pounds.

In North America, it is found from Hudson Bay to Alaska and from the Arctic Coast south to Northern Manitoba, Alberta, Saskatchewan, and British Columbia. It is also present in Eastern Siberia and Northern Mongolia. There is also an isolated population in the Upper Missouri River. Another isolated population was formerly present in the Upper Great Lakes area, including Northern Lower Michigan. The grayling was apparently gone from the Chain of Lakes area by 1900, and the last known one in Michigan disappeared from the Upper Penninsula in the 1930's. Its demise is thought to have been from habitat destruction brought about by logging and European settlement coupled with competition from expanding (possibly introduced) brook trout populations (the two species seem to be incompatible). Its habitat is cold, clear creeks and large rivers, and the shallow waters of cold, clear lakes.

Young grayling in lakes eat zooplankton, and gradually shift to aquatic insect larvae. Adults eat a variety of aquatic invertebrates as well as small fish and fish eggs. It is a schooling fish. It will readily take flies and leap when hooked, making it an attractive sport fish.

It spawns in early spring in small gravel or rocky-bottomed tributaries. The male is territorial, chasing away other males and making threatening displays by raising its large dorsal fin, spreading other fins, and opening its mouth. Spawning occurs during the day. No nest is prepared. The male clasps the female with his large dorsal fin (males have larger dorsal fins than females), both gape their mouth and vibrate, and eggs and sperm are released. The female typically lays 4,000-7,000 amber eggs, which sink to the bottom and adhere to objects. No parental care is provided. The eggs hatch in 13-18 days. Grayling mature in four to seven years, and may live 11-12 years.

Troutperch Family

The troutperch family evolved in North America about 45 million years ago. There are only two species in family, both found in North American. They are small fish with robust bodies and large heads, so named because they possess characteristics typical of both trout (adipose fin, unscaled head) and perch (toothed scales, fin spines, and mouth type). However, they are biologically related to neither.

Troutperch ***Percopsis omiscomaycus***
(the scientific names mean perch-like and [probably] after an Algonkian Indian word that includes the root word for trout)

The troutperch is pale olive green on its back and sides, with a silvery stripe along the lateral line, and five rows of dark spots—two on each side and one along top of back. Its belly is whitish. It has a translucent appearance. Its fins are lightly pigmented along the rays. Its average length is three to four inches, but it can reach six inches.

It is widely distributed throughout Central and Northern North America, including the Upper Mississippi River, Upper St. Lawrence River, Mackenzie River, Yukon River, Great Lakes, and Lower Hudson Bay Watersheds. It is found in large rivers, shallow waters of the Great Lakes, and in large inland lakes. It prefers clear to only slightly turbid water, and avoids shallow muddy areas.

Young troutperch feed on zooplankton. Adults eat a variety of bottom-dwelling aquatic invertebrates and occasionally small fish. It is, in turn, widely eaten as a forage fish. It is seldom seen or captured, even in lakes where it is abundant, but it is sometimes taken on a baited hook. It usually remains in deep water during day, but moves into shallow water after dark. In places, extensive on-shore-off-shore migrations have been observed. It prefers a water temperature of 50-60° F.

Spawning occurs from late April until June, when the water temperature reaches 60-68° F. It generally runs up tributaries to spawn, but spawning can also occur along lake beaches in water less than 3.5 feet deep. Troutperch congregate off the mouths of spawning streams and ascend after dark. It usually spawns and returns to the lake by sunrise, but some fish may remain in the stream spawning throughout the day. Spawning takes place near the surface and along the edges of the stream, over sand or rocks. No nest is built. Several males associate with each female. Males press close to the sides of the females, sometimes rising to the surface as eggs and sperm are released. Each female lays up to 2,000 large, yellow, non-adhesive eggs which sink to the bottom and fall between rocks or other crevices. No care is provided the eggs or young. Spawning may extend over several months. Few troutperch live longer than four years, and males mature and die earlier than females. Die-offs following spawning have been reported. Troutperch populations are known to fluctuate widely.

Cod Family

There are 60 species in the cod family, which is divided into three subfamilies. Members of the cod family are all characterized by having large heads; wide gill openings; small, round scales; a mouth at the tip of the snout with numerous small teeth in bands, one slender barbel on the chin, and soft fin rays. They mostly live in salt water in the northern hemisphere.

Burbot ***Lota lota***
(the scientific name comes from the name of this species in an ancient French dialect)

Burbot are the only truly freshwater representative of the cod family. The burbot, also commonly called lawyer or ling cod, is the only fish in this region with only one small barbel at the tip of its chin and the pelvic fins set forward of the pectoral fins (in the throat region). Coloration is a mottled yellowish brown to almost black on its back; sides; and dorsal, tail, and anal fins; with a whitish belly. The average adult length is 12-19 inches, but lengths of 40 inches and weights of 66 pounds have been reported.

The burbot is very widely distributed. It is found in most suitable habitats from the Arctic south to about 40 degrees North Latitude (about the position of Indianapolis) in North America, Europe, and Asia. It prefers large cool rivers and large lakes. In streams it prefers undercut banks. It prefers a water temperature of 60-65° F., and 74° F. is its upper limit.

It was historically one of the primary deep water predaceous fish inhabiting the Great Lakes, along with lake trout. Sea lamprey caused a serious decline in populations, but it has rebounded nicely with lamprey control measures.

Burbot are voracious feeders, eating mostly other fish (both living and dead), but also crustaceans, mollusks, other invertebrates, and fish eggs. Young burbot in turn are eaten by other fish. It is readily caught by anglers, especially during winter. The texture and flavor of burbot resembles cod and haddock, but it has never caught on with sport anglers. It has been utilized as a natural control for stunted panfish populations.

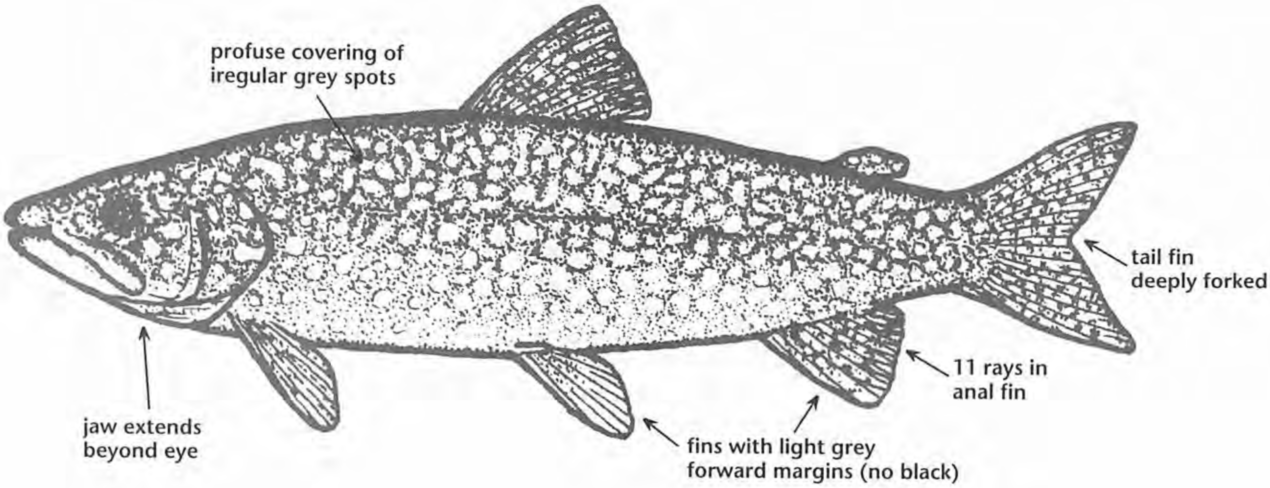
Burbot spawn in mid winter to early spring (January to March) before the ice melts. It utilizes rocky or gravelly bottoms, either in deep or shallow water. Spawning usually takes place at night. No nest is built, and no care is given to the young. During spawning, females swim about slowly, with tail lifted and head pointed down so far as to actually drag on the bottom. A male moves in behind and underneath, turns so their bellies are together, and eggs and sperm are released. The female then thrashes her tail stirring the water and scattering the eggs, which sink to the bottom. In some instances, writhing masses of spawning burbot have been observed. The eggs are small, and each female may lay over a million. The eggs hatch in four to five weeks. Newly hatched burbot prefer the shallow, sandy bottoms of lakes and may utilize tributary trout streams as nurseries, but may also be found in the open waters. It matures by age four, and may live 20 years.

Killifish Family

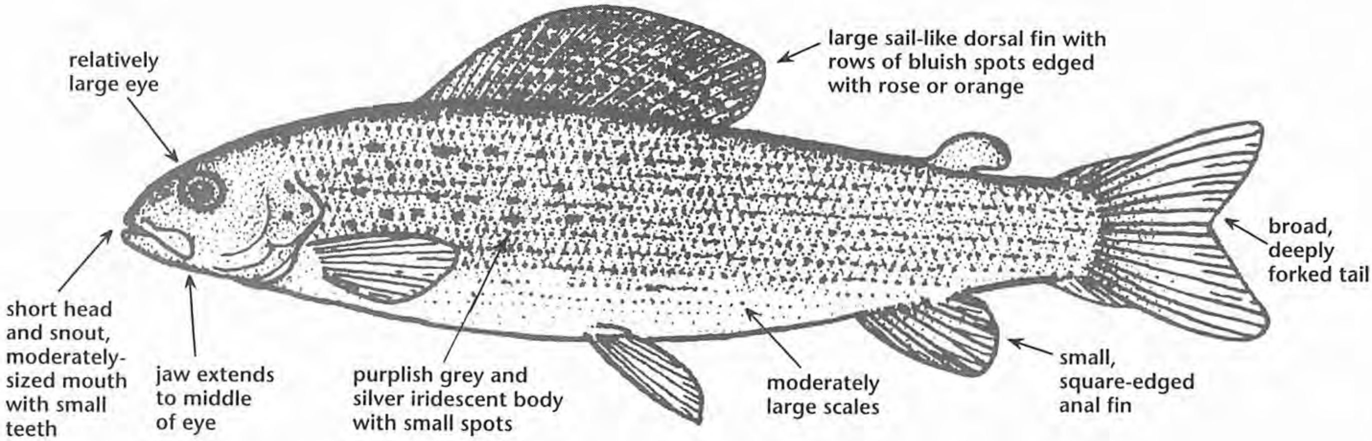
The killifish family contains 300 species in 45 genera. They are mostly found in shallow freshwater in the temperate and tropical areas of North and South America, Africa, Europe, Asia, and the East Indies. There are about 48 species and 10 genera in the U.S. and Canada. They are all small fishes with protruding lower jaws and angled mouths adapted for surface feeding.

Banded Killifish ***Fundulus diaphanus***
(the scientific names mean bottom abode and transparent)

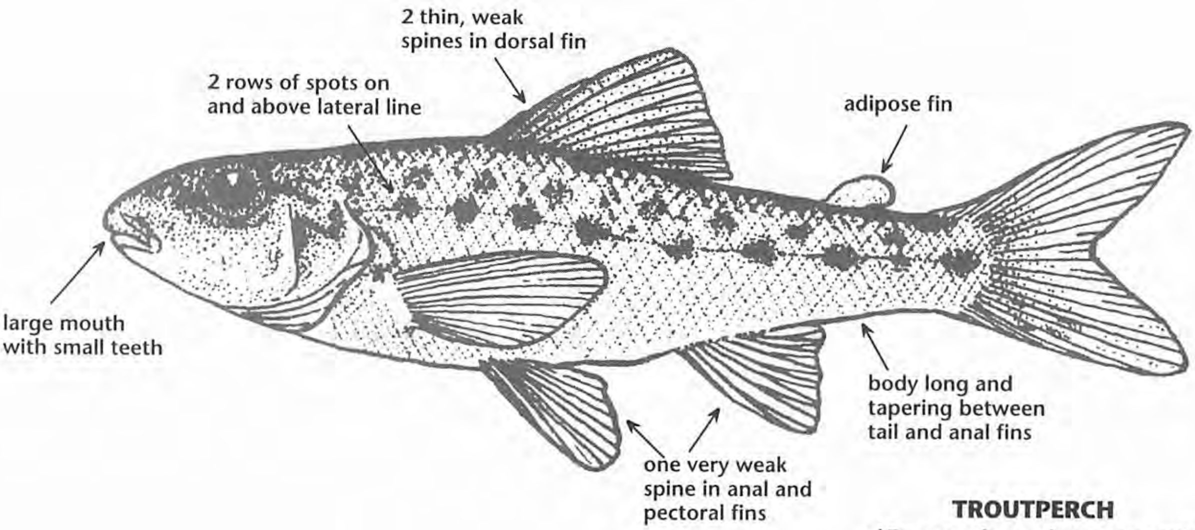
The banded killifish is a light olive color on its back and sides, and yellow-white on the lower half of its sides and belly. The dorsal fin of spawning males may develop a gold-



LAKE TROUT
(*Salvelinus namaycush*)



ARCTIC GRAYLING
(*Thymallus arcticus*)



TROUTPERCH
(*Percopsis omiscomaycus*)

green iridescence. Its average adult length is two to 2.5 inches, but it can reach a length of 4.5 inches.

Its range is along the Atlantic Coast from North Carolina to Nova Scotia, and in the St. Lawrence River, Upper Mississippi River, and Great Lakes (except Lake Superior) Watersheds. Within that area, it is found most frequently in the clear, shallow waters and estuaries (usually less than two feet deep) of large lakes and Lake Michigan, and in slow areas of medium to large-sized streams. It is locally common in many inland lakes throughout its range. It prefers broad, sandy shallow areas, either un-vegetated or in association with vegetation. It avoids swift, cold streams. It can endure temperatures to about 95° F.

The banded killifish eats zooplankton, insects and other larger aquatic invertebrates, fleshy seeds, and algae. It feeds night and day. In spite of its mouth adaptation for surface feeding, it feeds at all depths. Its is known to be prey for other fish and birds, but is not widely used as a bait fish. It is a schooling fish, often hiding in vegetation where its color and patterns provide good camouflage. It reportedly makes a good aquarium pet.

Spawning occurs from June until mid August, when the water reaches about 70° F. Males fight for territory, then pair with a female. Spawning occurs in floating weed masses. Males press the females against the weeds and vibrate, causing them to release a cluster of five to ten eggs. This spawning act is repeated every 15-30 seconds for about five minutes. Females can lay several hundred orange eggs. The eggs have adhesive threads which become entangled in the weeds. Eggs hatch in 11-12 days. It matures at two years of age.

Silversides Family

The silversides family evolved in fresh and brackish waters in Australia about 45 million years ago. There are about 165 species in 50 genera worldwide, and 12 species in eight genera from the U.S. and Canada. They are mostly found in salt water and are most widespread in tropical and temperate regions. There is only one species in Great Lakes Watershed.

Brook silversides *Labidesthes sicculus*

(the scientific names mean a pair of forceps and to eat, and dried or found in half-dried pools)

The brook silverside has a pale silvery green color with a prominent silvery stripe on its sides. Its body is translucent—almost transparent (which provides good camouflage). The scales on the top half of its body are outlined with dark pigment. Its fins are normally clear to only lightly pigmented, but during spawning the male's first dorsal fin develops a prominent black tip. It is a small fish, with the adult average length being only two to three inches. The oldest specimens can reach a length of four inches. Its appearance and habits make it one of the most distinctive fishes in the area.

It is found in Central North America, including the Mississippi River, Upper St. Lawrence River, and Southern Great Lakes Watersheds; and coastal areas from Georgia to Texas. It is common in many lakes and medium-sized rivers with moderate currents. It prefers clear water over sand or gravel bottoms, and avoids dense vegetation.

The brook silversides spawns from May through July. Males and females begin pairing when the water reaches 64° F. Spawning behavior involves swimming at the surface in tandem with the male on top and the female below. As the water warms, this paired swimming reaches a frenzy, with both fish sometimes shooting out of the water for a distance of three to four inches. Males sometimes establish a small territory on the water's surface in shallow water near shore, from which they drive off other males. Eventually, the paired fish "glide" toward the bottom at a 30 degree angle, with their abdomens making frequent contact with each other and releasing eggs and sperm. Spawning reaches its peak when the water is about 73° F. Females release 400-700 eggs. Eggs have a long adhesive filament which sticks to the first thing it touches. Eggs hatch in eight to nine days. The brook silversides spawns at the age of one and dies shortly afterward at an age of 15-17 months.

Young brook silversides form schools of up to 200 at the surface in an offshore area. They stay within about an inch of the surface, eating zooplankton and some algae and growing rapidly. Beginning about mid summer, they migrate inshore at night. Eventually, they remain in nearshore waters throughout the day.

The adult eats mostly insects. It is specialized for catching flying insects out of the air, although structures called gill rakers are well-suited for straining microorganisms from the water. It appears to be a sight feeder, often ceasing feeding when the water becomes turbid. At night, it becomes inactive, floating motionless (although it is attracted to light on the water at night). It remains inshore and at the surface beneath the ice during winter. It is commonly eaten by terns and other birds, and fish.

The brook silversides is a very active fish. Although it is well-camouflaged in the water, its habit of leaping out of the water and through the air in a low, graceful arch multiple times for distances up to ten times its length makes it easy to spot by people on the water. Locally it is sometimes called a skipjack.

Stickleback family

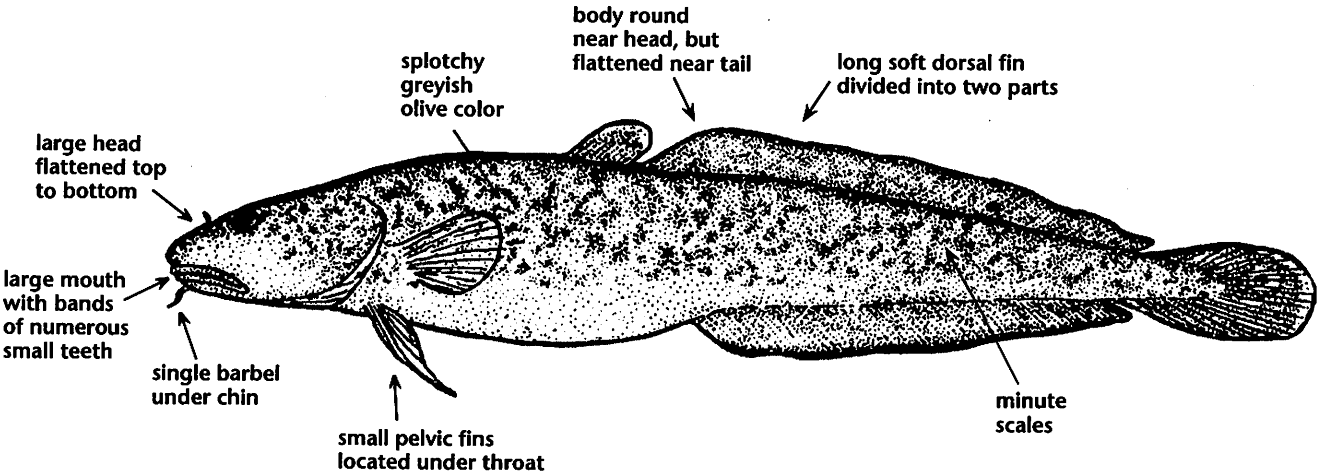
The stickleback family consists of a dozen species which reside in shallow areas of northern seas and fresh water around the globe. They are distantly related to the oceanic sea horses and tube-snouts. There are six species in five genera in North America, and two species in two genera in Great Lakes Watershed.

They are small, slender-bodied, scaleless fish with a small mouth slanted upward on the top part of the head. Their pelvic fins consist of a single well-developed spine, and they have a series of isolated dorsal spines (which probably help deter predators). The portion of the body between the tail and anal fins is distinctively flattened.

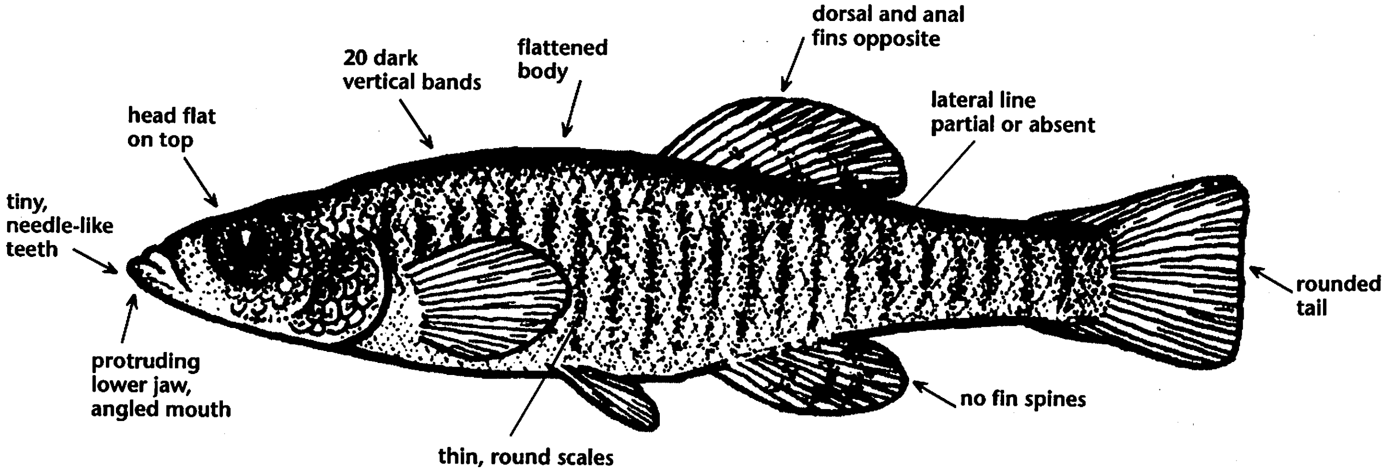
Brook stickleback *Culaea inconstans*

(the scientific genus name comes from a coined name and the species name means changeable or variable)

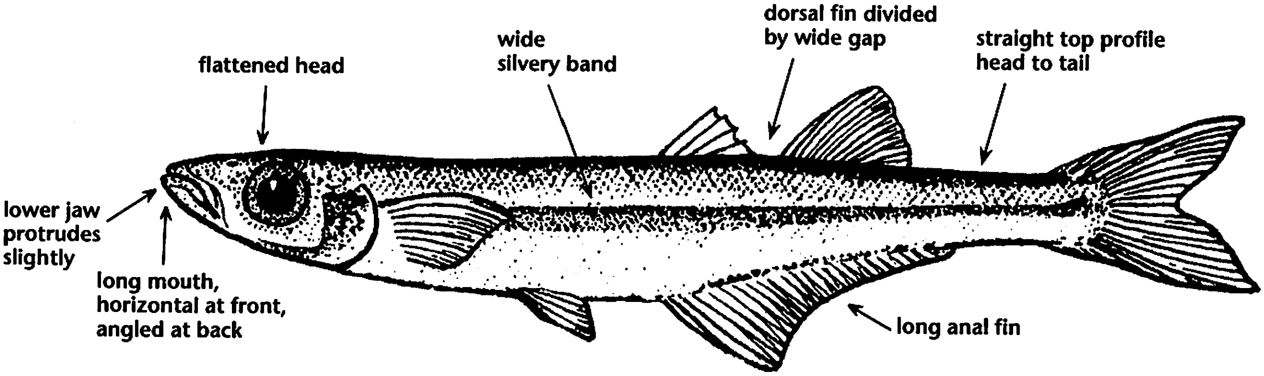
The brook stickleback is olive green on its back and sides, with variable white spots or light wavy vertical lines. It



BURBOT
(*Lota lota*)



BANDED KILLIFISH
(*Fundulus diaphanus*)



BROOK SILVERSIDE
(*Labidesthes sicculus*)

becomes lighter green to whitish on the belly. Males develop a black body and fins when spawning. Its average adult length is about 1.5-2.5 inches, with maximum length of only 3.5 inches.

It is found in North Central North America, including the St. Lawrence River, Upper Mississippi River, Lower Hudson Bay, Great Lakes, Lake Winnipeg, and Great Slave Lake Watersheds. It is widely present in the headwaters of small streams, and also in the shallow waters of the Great Lakes and inland lakes. It can be locally abundant. It prefers clear or only slightly turbid, cold waters; moderate to dense vegetation; and moderate currents in streams. It has a high tolerance for salt, and is sometimes found living in brackish water.

The brook stickleback eats a wide variety of aquatic invertebrates and small crustaceans, and to a lesser degree algae and fresh-water sponges. It has been observed burrowing and tunneling into silty bottoms in search of food. It appears to be preyed upon extensively by other fish.

Spawning can occur from late April to mid June, when the water reaches 46° F., but peak spawning occurs when the temperature is 59-66° F. At this time, the brook stickleback moves from deep to shallow water and establishes a territory which it defends against all other small fish. The male builds a ball-shaped nest 0.75 to two inches in diameter out of organic debris, filamentous algae, and other material, in an area of vegetation (preferably Chara). The nest is usually attached to a plant stem within a foot of the bottom. A whitish cement produced by its kidneys is used to bind the nest together. The female enters the nest through a single opening, lays up to 100 orange eggs, and departs. The male then enters and fertilizes the eggs. Afterwards, he guards them and fans fresh water into the nest with his fins. He sometimes builds a second nest and transfers the eggs there. The eggs hatch in about seven to eleven days. After hatching, the male remodels the nest into a nursery by partially pulling it apart. The young only remain in the nursery for several days before swimming away. They mature in one year, and seldom live past three.

The brook stickleback congregates in schools. It may migrate extensively within stream systems. It is known for its elaborate behavior patterns, and makes an interesting aquarium pet (but will attempt to kill other small fish kept with it).

Ninespine stickleback *Pungitius pungitius*
(the scientific names mean pricking)

The ninespine stickleback is dark to yellow-green on its back and sides, with irregular dark bars or mottling. The lower half of head and belly are silvery. Spawning males develop a black belly and white pelvic fins. Its average adult length is about two inches, with maximum length being only three inches.

It is widely distributed in both fresh and nearshore saltwater throughout the Earth's northern hemisphere. In North America, it is found south to the Great Lakes. Its habitat is the shoal waters of the Great Lakes and the mouths of tributary streams. It is known from some large inland lakes in the Lower Peninsula, but its presence in the Chain of Lakes not well-documented. It prefers cool, quiet waters. It is found in shallow water during summer, but moves into deeper water in winter.

The ninespine stickleback primarily eats crustaceans, either zooplankton or larger invertebrates. It is widely utilized as a forage fish. It is preferred over juvenile smelt by young lake trout.

It begins spawning in early June and continues through July. It spawns over mucky bottoms at depths of 40-150 feet. Its nest is a simple burrow, 0.5 inch wide and 1.5 inches long, either in mucky bottoms, crevices in rocks, or masses of vegetation cemented together. The female enters the nest, turns around, deposits her eggs, and leaves. She can lay up to 150 eggs, usually in clusters of 20-30. The male then enters to fertilize the eggs. The male drives off other males by chasing and biting. He guards and cares for the eggs and young. The young congregate in shallow sandy areas until late fall, when they head for deeper water. Most mature by one year of age, and they can live for four years. However, most males die after spawning.

The ninespine stickleback uses its pectoral fins for swimming more than its tail fin.

Sculpin Family

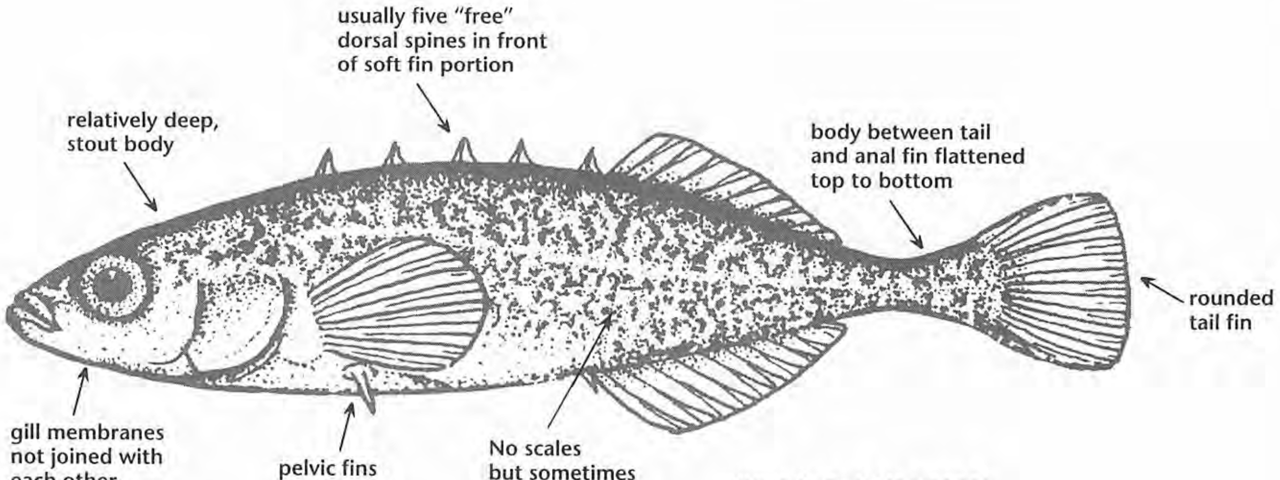
The sculpin family evolved about 30 million years ago. They are considered among the most highly evolved fishes. There are about 300 species worldwide, mostly in salt water, with about 111 species in North America, and four species in the Great Lakes Watershed.

This family is characterized by having large, flattened (top to bottom) heads with close-set eyes on top; a robust body forward tapering to a thin tail section; strong jaws with numerous short, blunt teeth; large pectoral fins (which they use to support themselves on the bottom, giving them a kind of prehistoric appearance), spines on the bone between the eye and the gill cover, and an absence of scales (but sometimes with bony "prickles" instead). They are generally bottom-dwelling fish.

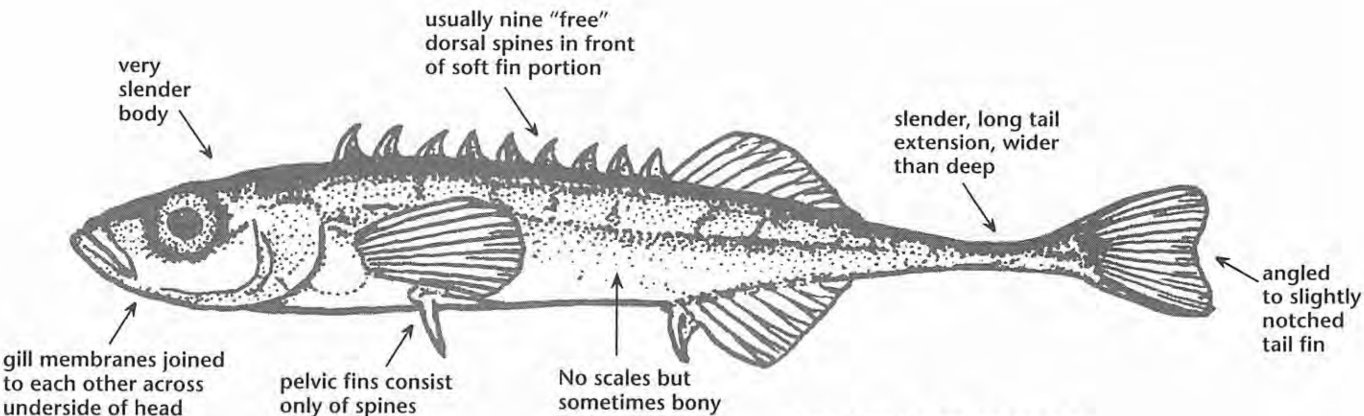
Mottled sculpin *Cottus bairdi*
(the scientific names mean the bulls head, an old common name of a European sculpin, and after Spencer Baird, the first U.S. Fish Commissioner)

The mottled sculpin has a brown to tan head, back, and sides with darker to blackish splotches or mottling. Its undersides are whitish; and its fins have pigmented spots, bands, or speckles. It is very similar to the slimy sculpin. Another common name is muddler (a popular type of fishing fly is called a muddler minnow). It usually grows to three to four inches, but specimens up to 5.5 inches have been collected.

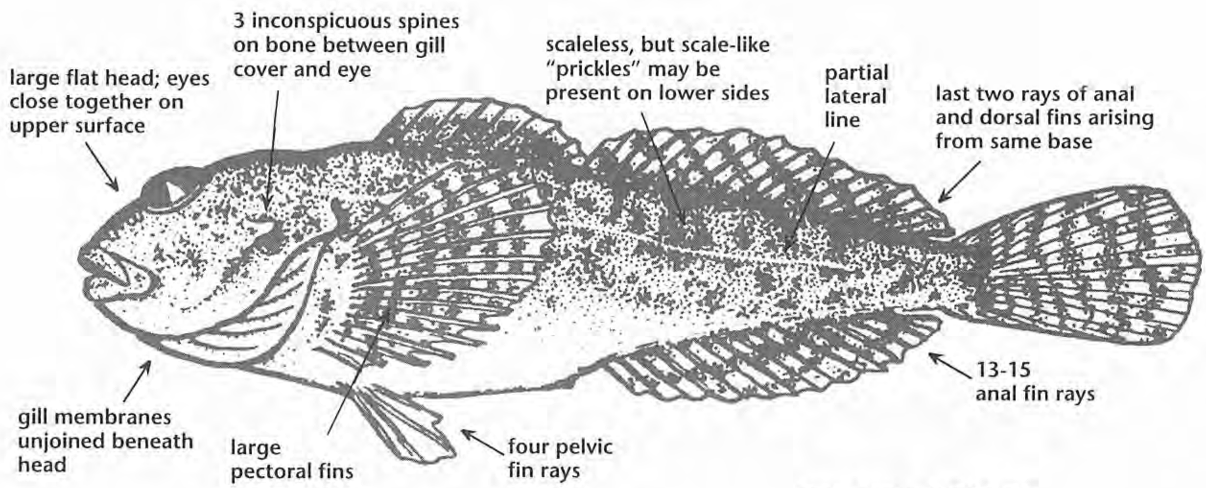
The mottled sculpin is found mostly in the northeastern part of North America (including the St. Lawrence River, Great Lakes, Lake Winnipeg and Lower Hudson Bay Watersheds), as well as the Columbia River Watershed and parts of the Rocky Mountains. It generally prefers cool, clear waters (although warmer water than the slimy sculpin). It is common along the shores of lakes and in the mid-reaches of trout streams. Frequently, it is the most common fish in streams. It likes to hide under rocks or logs



BROOK STICKLEBACK
(*Culea inconstans*)



NINESPINE STICKLEBACK
(*Pungitius pungitius*)



MOTTLED SCULPIN
(*Cottus bairdi*)

and their distribution is more dependant on shelter than on bottom type.

It mostly eats aquatic insect larvae and amphipods, but it is also known to eat leeches, tiny fish, fish eggs, plant remains, and algae. It has been implicated in eating too many trout eggs, but studies have shown that they mainly eat eggs which have not been properly covered and which would not have survived anyway. In turn, they are eaten by trout.

The mottled sculpin spawns in April and May, when the water temperature is between 48-57° F. The male prepares a nest cavity under a rock or log. He develops distinctive spawning colors and a behavior said to resemble the movements of a barking dog. He bites females (a courtship routine) and intruding males (to drive them away). A single female enters the nest and, while upside down, lays hundreds of sticky eggs which adhere to the roof of the cavity. She may stay in the nest for several days. After she leaves, other females may enter the nest and lay more eggs on top of hers. Eggs hatch in two to three weeks. The male remains to guard the eggs and fry until they leave the nest, usually by late May. Most individuals live less than three years.

The mottled sculpin is host to the larval stages of several species of mollusks. It is most active at night, and is somewhat social, but does not form schools.

Slimy sculpin *Cottus cognatus*
(the scientific names mean the bulls head, an old name of a European sculpin and related to another European species)

It has a dark greenish-brown head, back, and sides with darker mottling. Two characteristic dark "saddle" marks are present under front portion of the dorsal fin. Its undersides are light or whitish and its fins have pigmented spots, bands, or speckles. The slimy sculpin is very similar in appearance to the mottled sculpin. Its average length is about three inches, and it can reach almost five inches.

The slimy sculpin's range is Northern North America (from the Great Lakes, St. Lawrence, and Upper Mississippi River Watersheds north to the Arctic Ocean), and in extreme Eastern Siberia. It is found in the Great Lakes and deep inland lakes, as well as in swift, cold, rocky-bottomed streams in association with vegetation. Its preferred temperature is between 48 and 54° F., with an upper lethal temperature of 79° F. It seems to prefer constant temperatures, and prefers colder temperatures than mottled sculpin. It is often found in association with trout.

It forages on the bottom for amphipods, insect larvae, worms, snails, and fish eggs (probably feeding mostly on lose trout eggs which have not been buried in gravel). In lakes, it is an important item in the diet of lake trout and burbot.

Spawning occurs in late April to May. Its spawning behavior is similar to that of the mottled sculpin. In streams, its nest is a cavity under some flat object excavated by the male. He carries large objects away from the nest in his mouth, and washes lighter materials away by fanning with his fins. He defends the nest with a "barking" action. The male drives the female into the nest, where she lays 100-600 eggs on the "ceiling." He guards the eggs, which hatch in about 30 days. The young leave the nest in three to six days and begin to feed. The spawning habits of lake-dwelling slimy sculpin are not well known, but there is evidence that they may spawn in water as deep as 250 feet, and deposit their eggs in clumps on the bottom. In lakes, the young live in open water until fall, when they migrates to the bottom. It matures between ages two and four, and can live about five years.

When disturbed, slimy sculpins have the habit of quickly swimming in a circle and then diving down and burying themselves in loose sediment. It is active at night, often moving into shallow water and retreating to the dark depths during the day. In the nearby Jordan River, Michigan, studies have revealed densities of up to 34,400 sculpins per surface acre of stream. In some Minnesota trout streams with a total fish production of about 175 pounds per acre, sculpins commonly account for about 60 pounds per acre.

Deepwater sculpin *Myoxocephalus thompsoni*
(the scientific names mean head like a doormouse and after the Reverend Zadock Thompson, a Vermont author)

The deepwater sculpin has a greyish to light-brown back and sides. Its undersides and the portion of the body between the anal and tail fin is lighter. There are usually four to seven "saddle" marks on its back. Only the first dorsal fin is pigmented, but the others have speckles or bars. Its average length about 5.5 inches, but it can reach almost eight inches.

The deepwater sculpin ranges throughout the northern portions of Europe, Asia, and North America in deep inland lakes and in nearshore salt or brackish water. In North America they are found throughout Canada in deep lakes and in the Great Lakes Watershed (which marks their most southerly limit worldwide). In the Great Lakes Watershed, Torch Lake is the only inland lake from which it is known.

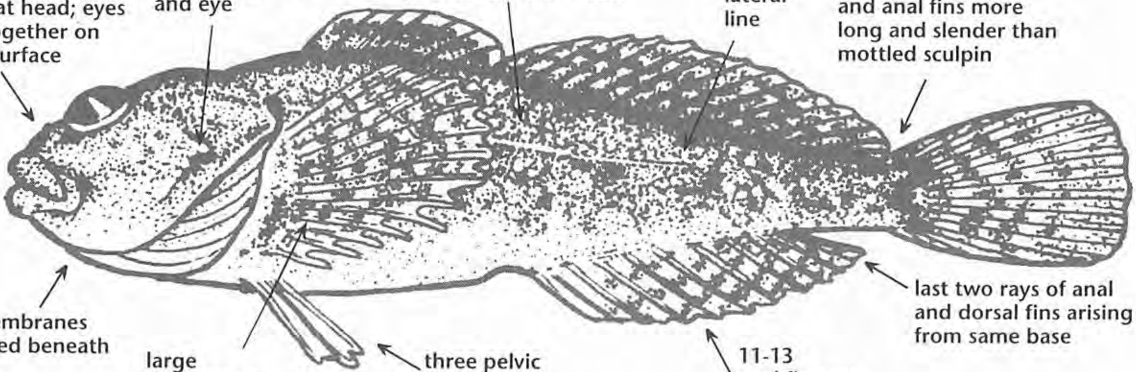
It is considered a "glacial relict," because it was originally though to occupy arctic marine or brackish waters, but was "pushed" south along with salt water in front of advancing ice sheets and then stranded behind in lakes created by the glaciers.

It inhabits waters in the Great Lakes to depths of over 1,000 feet. In Lake Michigan, the shallowest water from which it has been taken was about 40 feet, and it is most abundant at about 300 feet. It prefers water less than 40° F.

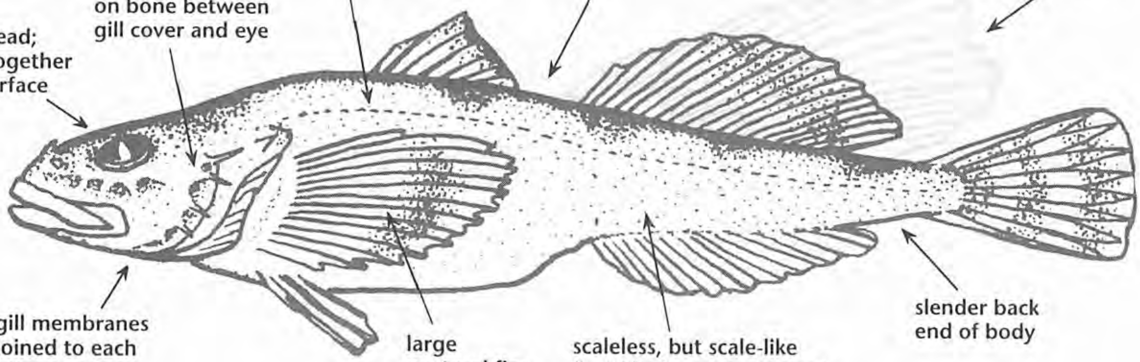
It feeds mostly on small crustaceans and aquatic insects, but also on fish eggs, algae, and zooplankton. Historically, it has been very important as food for lake trout and burbot. Because it mostly lives in total darkness in very deep waters, very little is known about it. In Lake Michigan, there is evidence of spawning in deep water during winter. However, studies elsewhere have indicated spawning during summer or early fall. It is possible that year-round spawning occurs in some areas. Alweives concentrate in deep water where sculpins spawn, and their abundance is thought to be responsible for a decline in the abundance of deepwater sculpins in the Great Lakes.

Sunfish Family

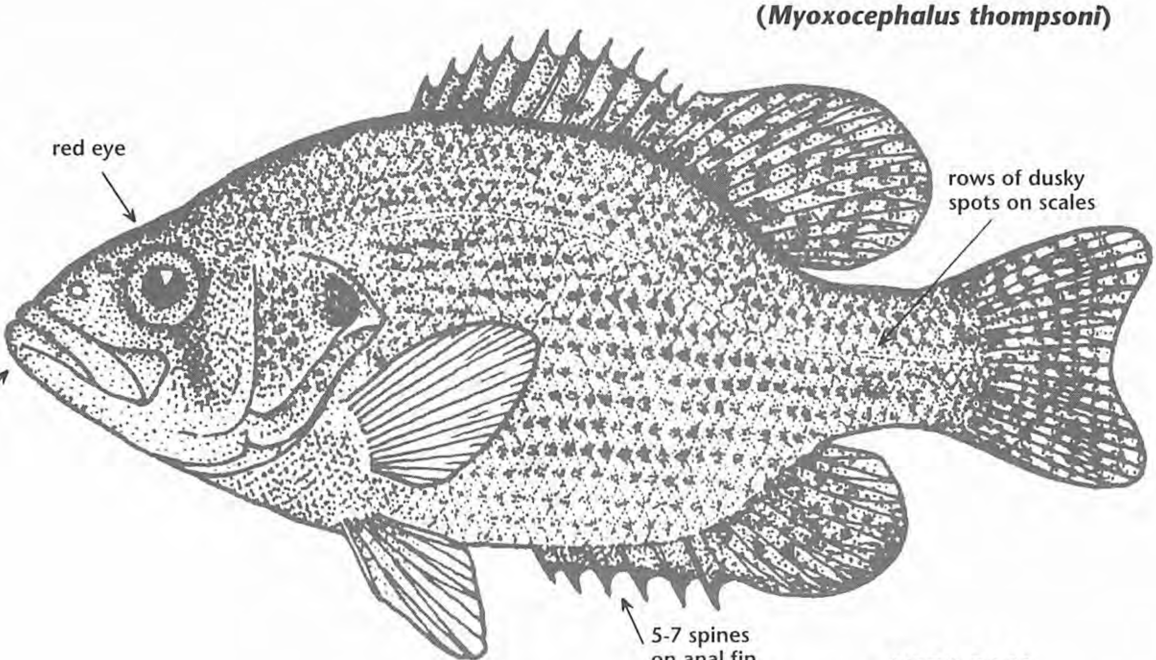
The sunfish family evolved in the Mississippi Valley about 30 million years ago. It is a diverse family, consisting of 32 species in nine genera, all of which were naturally



SLIMY SCULPIN
(*Cottus cognatus*)



DEEPWATER SCULPIN
(*Myoxocephalus thompsoni*)



ROCK BASS
(*Ambloplites rupestris*)

found only in North America. However, they have been widely introduced worldwide. There are 12 species in four genera in the Great Lakes Watershed.

They are generally small to moderate-sized, colorful fishes with deep, rounded bodies strongly flattened side to side. They have large eyes, a single (but sometimes barely so) dorsal fin divided into spiny and soft-rayed portions, an anal fin with both spiny and soft rays, scales with rows of teeth on the back edge, fine teeth in brushlike pads on upper and lower jaws, and fine or molar-like teeth at the back of the throat. Hybridization is common among members of the sunfish family.

Rock bass *Ambloplites rupestris*

(the scientific names mean blunt armature and living among rocks)

The rock bass is brown to olive green on its head, back, and upper sides, becoming lighter on lower part of body. It has eight to ten horizontal rows of spots on its sides below the lateral line. It has a red or orange eye. All of its fins are pigmented, and the dorsal, anal, and tail fin have white spots. Its young may have black and white "marbling" on sides. Spawning males become blackish. The average adult length is six to eight inches, but lengths up to 14 inches and weights up to 3.75 pounds have been recorded.

Its range is East Central North America, including the St. Lawrence River, Mississippi River, Great Lakes, and Lake Winnipeg Watersheds. It is common in the nearshore, shallow waters of the Great Lakes, inland lakes, and medium to large streams. It prefers clear, cool waters over a rocky or gravel bottom, with some vegetation present. It seems to prefer water of about 70° F., with the upper limit being about 100° F. It cannot tolerate low oxygen levels (less than two to three parts per million).

Rock bass young feed on zooplankton or insect larvae. Adults eat insects, crayfish and other aquatic invertebrates, and small fish. Studies have shown that morning and evening are its best feeding times.

It spawns in very shallow water during late May to early June when water temperatures reach 60-70° F. Males build circular, dish-shaped nests eight to ten inches in diameter by washing away sand and debris from an area of gravel. Females congregate nearby, and a single female approaches a nest when she is ready to lay eggs. The male and female line up head to tail (the female reclining on her side) and display a peculiar rocking motion. The female only lays a few yellow-white eggs at a time for a period of an hour or more, but she may lay up to 5,000 during spawning. The eggs adhere to the gravel, and hatch in three or four days. After the eggs are laid, the male guards and tends the nest. A few days after hatching, the young disperse in shallow areas, preferably in or near vegetation, and fend for themselves. It matures in two to four years, and can live for 13 years in the wild (up to 18 in captivity).

The rock bass is active at night. It seems to be a rather sedentary fish, without much inshore-offshore movement. It can change colors rapidly to blend in with background colors, and has been called the chameleon of the sunfish family. It bites readily, is easily caught (although it is rated as a poor fighter), and tastes good (Figure 33). In winter, rock bass inhabit deep areas and remain in a state of semi-hibernation.

Figure 33 - Anglers can often count on catching rock bass when not much else is biting. Billy Marzella shows off a nice "rockie" taken from Six Mile Lake.

Green sunfish *Lepomis cyanellus*

(the scientific names mean scaled gill cover and blue)

The top half of the green sunfish's body is olive brown with many greenish reflections. Its sides are lighter with seven to 12 faint dark vertical bars. It has a yellow or white belly. Its head has emerald spots and sometimes lines radiating backward. Its gill has a black flap with a wide, light margin. Its fins are usually pigmented. The rear bases of its dorsal and anal fins have a dark blotch. Spawning males develop a prominent light line along edge of dorsal, tail, and anal fins. The average adult length is four to five inches, but lengths up to 11 inches and weights greater than two pounds have been recorded.

The range of the green sunfish is East Central North America, including the Great Lakes, Southern Hudson Bay, and Mississippi River Watersheds. It lives in the warm, shallow (usually less than five feet deep) waters of lakes and moderate-sized, slow moving warm water streams in the vicinity of weed beds.

In Michigan, it is most common in the southern part of the state. It tolerates both clear and turbid water. It can stand more turbidity and silt than any other sunfish in the Chain of Lakes, but cannot tolerate low oxygen levels. Its preferred temperature is about 80° F.

Young green sunfish eat zooplankton, and adults eat zooplankton, insects, snails, small fish, and crayfish. It has also been known to eat vegetation. It bites readily, but is not sought after by anglers because it is usually quite small. The green sunfish is sedentary, and appears to develop a home territory. It is active at dawn and dusk.

It spawns from late May through July when the water temperature is between about 60 and 80° F. Males build nests in water less than 1.5 feet deep. Nests are often surrounded by logs, rocks, or vegetation. Sometimes, nests built by other sunfish are used. The male creates a shallow depression six to 14 inches in diameter using his tail. Sometimes, many nests are constructed in a small area. He defends his nest and territory against intruders. Males, and sometimes females, grunt during courtship. A paired male and female circle the nest side by side. The female pauses briefly, tilts on her side, and lays eggs, which are then fertilized by the male. After egg laying, the male expels the female from the nest area. The eggs hatch in only two to three days. Young fish swim away from the nest and begin feeding after about five days. They mature between one and three years old, and can live for ten years.

Pumpkinseed sunfish *Lepomis gibbosus*
(the scientific names mean scaled gill cover and like a full moon referring to body shape)

The pumpkinseed sunfish has an olive-brown back, lighter sides, and a reddish or orangish breast and belly. Its back and sides have orange, yellow, blue, and green spots. It has seven to ten faint vertical bands on sides, most prominent in females. Narrow, wavy, blue-green lines, alternating with orange-brown lines, radiate back from its snout and eye. Its gill flap is black with a thin light margin and a larger reddish spot at the back edge. Its dorsal, tail, and anal fins have brown spots. The average adult length is five to 7.5 inches, but lengths up to ten inches and weights up to one pound have been recorded.

Its original range was Eastern North America, including the Upper Mississippi River, Lake of the Woods, Great Lakes (except Lake Superior), and Upper St. Lawrence River Watersheds; and the Atlantic Coast from Nova Scotia to Georgia. However, it has been widely introduced in other parts of North America and Europe. It is common in weedy ponds and lakes, and in low-gradient streams. It prefers cool to moderately-warm waters which are clear to only slightly turbid. It prefers water temperatures between 75 and 89° F. It cannot tolerate water over 100° F.

Its food includes zooplankton, a wide variety of other aquatic invertebrates (including aquatic and terrestrial insects and mollusks), and larval fish. It appears to eat snails more than other sunfish, possibly because of the molar-like teeth in its throat. It feeds throughout the day, but not normally after dark, when it rests.

The pumpkinseed sunfish spawns between early May and August, when water temperatures reach 55-63° F. Nests are circular depressions, usually about one foot in diameter in water less than two feet deep. Nests can occur singly or in groups. The male constructs the nest by washing the bottom with his tail and removing large objects with his mouth. He defends a territory within about three feet of the nest by chasing, biting, and spreading his gill flaps wide. A female approaches the nest, and is then driven into it by the male. The spawning act is the same as described for the green sunfish. The male guards the nest and drives away all intruders (he will even bite human hands and fingers) until the young hatch. Sometimes, he even guards the young, but not usually. Females produce from 2,000 to 7,000 eggs. The eggs sink and stick to objects in the nest (i.e. gravel, stones, roots, and sticks). The young leave the nest soon after they hatch, but remain in shallow water in the vicinity of the nest. In the wild, the pumpkinseed sunfish can live ten years (12 in captivity). It matures between one and three years of age.

The pumpkinseed sunfish is considered one of the most colorful and beautiful North American freshwater fish. Large numbers of juveniles travel in loose schools. Adults are often found in pairs or small groups, but do not school. Overpopulation and resulting stunted growth is often a problem in lakes.

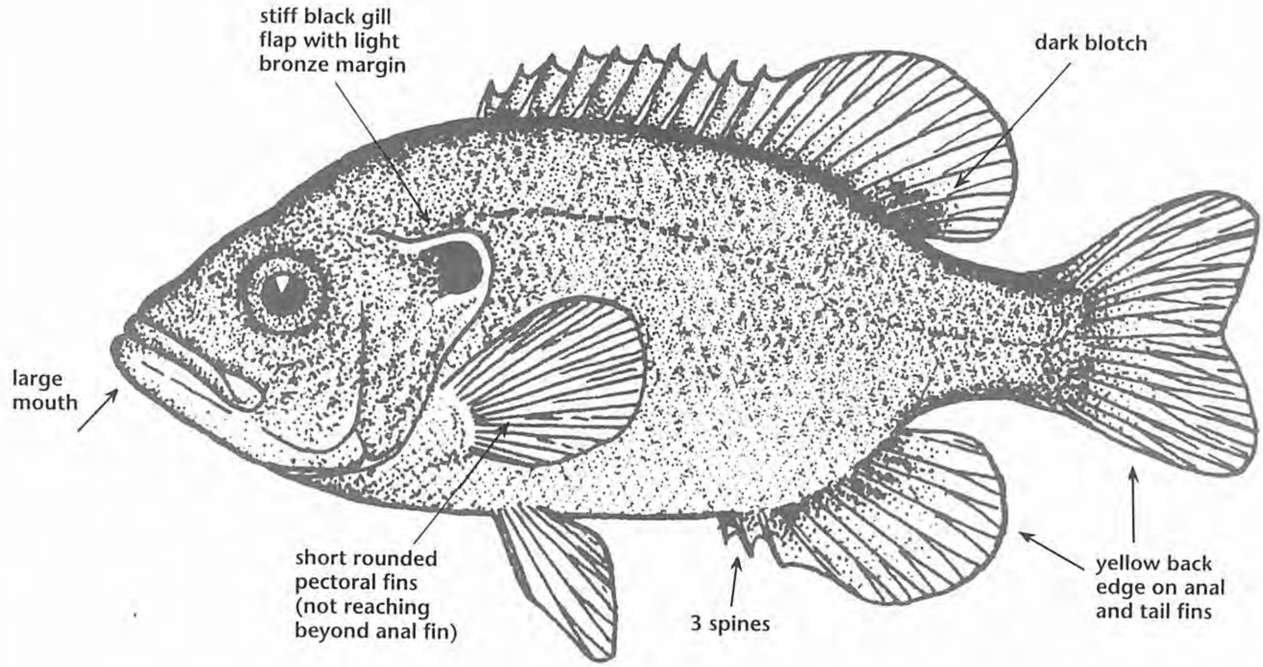
Bluegill *Lepomis macrochirus*
(the scientific names mean scaled gill cover and large hand, possibly in relation to size or shape)

The bluegill has a greenish-brown back, green or brown sides (sometimes with blue or purple tints) and five to nine double vertical bars (most prominent in the young). Its throat and belly are either white, yellow, or red-orange. Its gill flap is black. Blue lines extend back from its mouth and chin. Its fins are brown-pigmented, and a dark blotch is present near rear of dorsal fin. Spawning males develop a orange breast, blue sheen, and dusky pelvic and anal fins. The average adult length is five to seven inches, but lengths up to 15 inches and weights of more than four pounds have been recorded (in the southern U.S.).

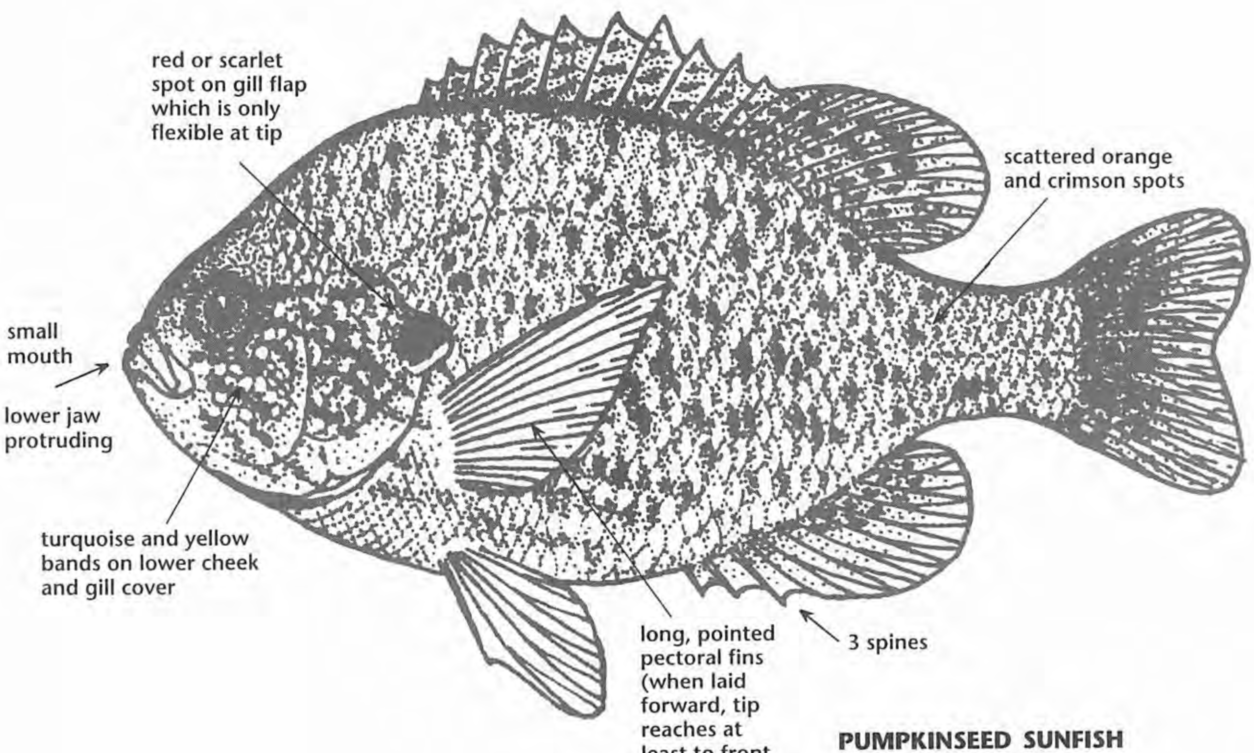
Its original range was the freshwaters of Eastern and Central North America, including the Great Lakes and Mississippi River Watersheds, and along the east coast from Virginia to Northeast Mexico. However, it has been introduced almost everywhere throughout the U.S. as well as Africa and possibly other continents. It is present in most medium to large, sluggish to moderately swift, warm water rivers and in inland lakes. It is Michigan's most abundant sunfish. It prefers clear water with a moderate amount of vegetation. Its preferred temperature is about 80° F. It does not tolerate low oxygen levels well.

Young bluegills mainly eat zooplankton, while adults eat aquatic insects, aquatic plants and algae, small crayfish, and small fish (including their own young). Small bluegills are utilized widely for food, but few other fish prey on larger adults.

Spawning occurs from late May to August, when water temperatures reach 67-80° F. Males appear first at the spawning site, which is generally a sand or gravel shoal.



GREEN SUNFISH
(*Lepomis cyanellus*)



PUMPKINSEED SUNFISH
(*Lepomis gibbosus*)

Using his fins, the male washes out a crater-shaped excavation two to six inches deep and about one foot in diameter in water one to five feet deep. Colonies of nests are usually constructed. The male defends the nest against other fish. He circles the rim of the nest to attract a female, and also makes grunt-like calls. The male and female then circle the nest together. The female tilts sideways so that her belly is against his, and eggs and sperm are released. This process is repeated many times. She may lay 2,000 to 8,000 eggs, in more than one nest. The eggs sink and stick to objects in the nest. Eggs hatch within three days. Shortly after hatching, the male stops caring for the young. The young can grow rapidly, reaching a length of 1.5 inch by the end of the summer. Bluegills mature between one and three years of age, and can live 11 years.

Bluegills often swim in loose schools of 10-20 fish. Activity and feeding are greatest at dawn and dusk. Schools sometimes move onshore at dusk and offshore after sunrise. Bluegills form aggregations during winter. Like the pumpkinseed sunfish, it has a tendency to become overpopulated and stunted.

Longear sunfish *Lepomis megalotis*
(the scientific names mean scaled gill cover and great ear, in reference to the long, wide flap on the gill cover)

The longear sunfish is olive-green to rusty-brown on its back, and lighter on its sides. Its back and sides have yellow, orange, blue, or green spots, and sometimes eight to ten vertical bars. It has a yellow to red-orange breast and belly. Its cheeks are orange with wavy blue streaks extending back from its mouth and eye. Its gill flap is black with a narrow reddish or yellowish band around the edge. The dorsal and anal fins are greenish or rusty colored. The back part of dorsal fin has parallel rows of light dots. Spawning males develop an iridescent green color on top, a bright orange on the lower half, and blue-black pelvic fins. The average adult length is 2.8-3.7 inches, but lengths up to nine inches and weights of 10 ounces have been recorded.

Its range is East-Central North America from Southern Quebec west to Central Minnesota, and south (west of the Appalachians) to the Gulf Coast and Northeast Mexico. Northern Michigan is near the northern limit of its range. It primarily inhabits clear, shallow, still, warm water with areas of vegetation, and is only occasionally found in lakes. It does not tolerate muddy water. As a result, its range is decreasing in some areas.

The longear sunfish eats aquatic insects, zooplankton, fish eggs, and fish fry. It seems to feed more at the surface on mature insects than other sunfishes. It becomes inactive in darkness, resting on the bottom, although it has been observed feeding in bright moonlight. It is a sedentary species with a small home range—only 30 to 60 yards. It has a strong homing ability based on a sense of smell. It is too small, and populations are usually too sparse, for it to be of much interest to sport anglers.

The longear sunfish spawns from June through early August when water temperatures reach 74-77° F. The male builds a nest in gravel (when available), or in sand or hard mud. Nests are most commonly built in water less than two feet deep, but sometimes in water up to 12 feet deep. Nests are sometimes constructed in colonies, often so close that their rims touch. Males chase other fish from their territory, which is the area of the nest and the water in a zone about three feet above it. Spawning activity peaks in the afternoon. Spawning behavior is similar to that described for other sunfish. Eggs hatch in three to five days, and feeding begins about a week later. Few longear sunfish live to be four years old, but fish up to nine years old have been found.

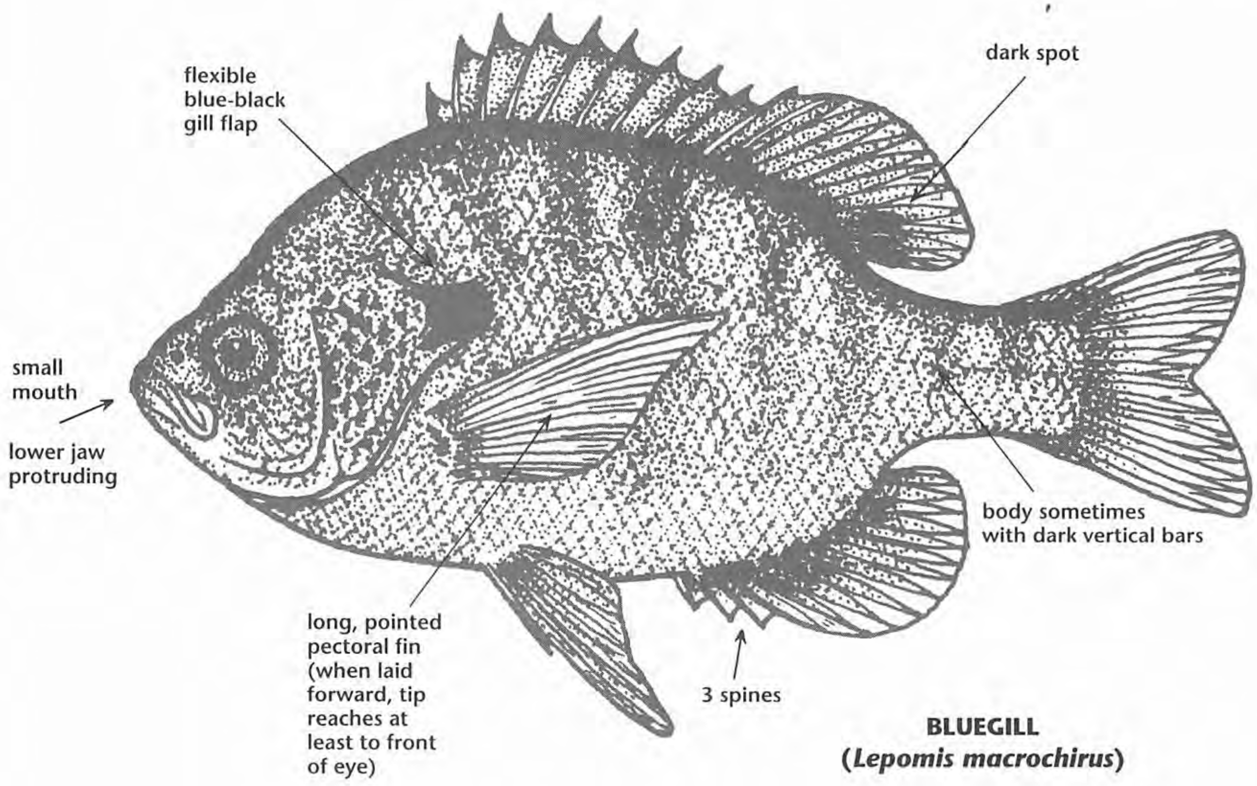
Smallmouth bass *Miocropterus dolomieu*
(the scientific names mean small or short fin, apparently based on a specimen with a damaged or deformed dorsal fin, and after M. Dolomieu, a French mineralogist and friend of the zoologist who first described this species)

The smallmouth bass is green to greenish brown or bronze on its back and head, becoming lighter on its sides, and light yellow to white on its belly. A common name in some places is "bronze back." In the clearest lakes of the Chain, where its color is almost bright green, it is sometimes called a green bass. It has nine to 16 faint vertical bars on its side, and three dark streaks on its head radiating backward from its snout and eye. Its eyes are red or orange. There is a dark spot on its gill cover about size of its eye. Breeding males develop a darker color. The young have a distinct marking on the tail fin—yellow at base, a dark crescent through middle, and a whitish edge. The average adult length is nine to 14 inches, but it may reach 25 inches and weigh 10 pounds.

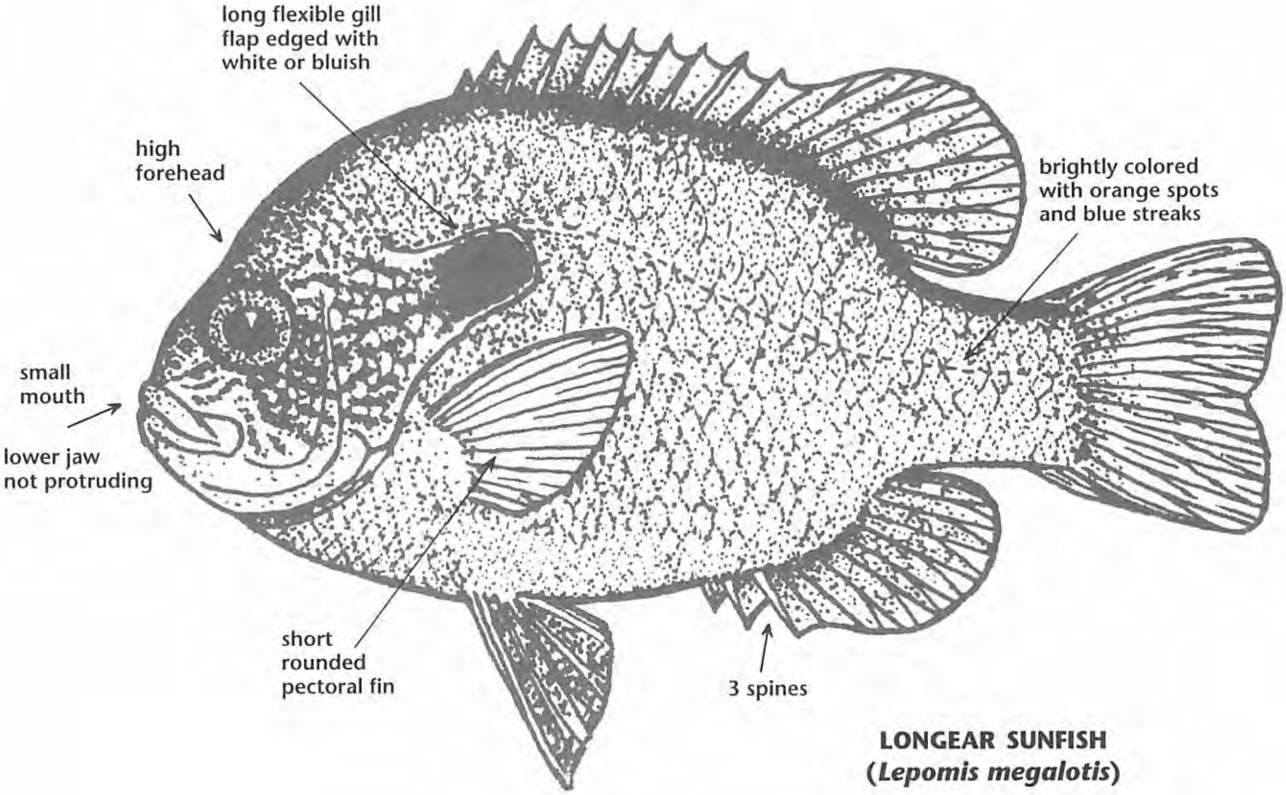
Originally the smallmouth bass was found in East Central North America, including the Great Lakes, St. Lawrence River, and Upper Mississippi River (except the Missouri River portion) Watersheds. It has been introduced throughout the U.S. as well as in England, Mainland Europe, and Africa. It is found most often in medium to large, cool, swift rivers; in the shallow waters of large, clear lakes over rocky or sandy bottoms; and in certain nearshore waters and bays of the Great Lakes. It prefers water temperatures from about 68 to 72° F. It becomes lethargic and inactive below about 50° F. It avoids thick weed beds.

The newly hatched young eat zooplankton or tiny insect larvae. By the time it reaches 1.5 inches, it is eating larger insects and tiny fish. When it reaches three inches, it begins eating small crayfish. Fish are the main food of adults.

The smallmouth bass spawns from mid May through July when the water reaches 55-64° F. Sudden drops in water temperature or the onset of silty conditions during spawning can reduce spawning success. Nests are constructed on gravel or stones, usually in water from two to five feet deep. Most nest building takes place in early morning, and takes several days. The male builds the nest by sweeping the stones or gravel clean with its tail. Large objects may be removed with its mouth. The female approaches the completed nest, and is driven onto it by the male. She tilts on her side, the male moves alongside in an upright position, and eggs and sperm are deposited during a four to six second period. This happens every 30 seconds or so for several hours, until 2,000-10,000 eggs are laid. The eggs sink and adhere to the bottom. The male remains to guard the nest (but sometimes



BLUEGILL
(*Lepomis macrochirus*)



LONGEAR SUNFISH
(*Lepomis megalotis*)

smaller fish manage to raid it anyway). Eggs hatch in two to 10 days, depending on water temperature. Young remain in the nest for up to two weeks, after which they remain in a school for a while before dispersing throughout the shallows. The male may attempt to guard the young for up to four weeks. Smallmouth bass mature at three to four years of age, and can live up to 13 years.

The smallmouth bass is most active at dawn and dusk, often lying along a log, boulder, or rocky ledge. At night it ordinarily lies asleep on the bottom, but may remain active when the moon is bright. In winter it becomes semi-dormant in deep waters. Adults do not school, but may form loose aggregations. It is non-migratory and tends to stay in a home area. It is a popular sport fish and has the reputation of being "inch for inch and pound for pound, the gamest fish that swims." Studies of lakes with smallmouth bass have shown standing crops of two to 74 pounds per acre.

Largemouth bass *Micropterus salmoides*
(the scientific names mean small fin and trout like, possibly in reference to its fighting and food qualities)

As the name implies, this species has a large mouth, with the upper jaw reaching at least to the back edge of the eye. Its back and head are usually dark green to dark olive brown, with lighter sides and a whitish underside. A prominent, but interrupted, dark lateral stripe runs from the snout to the tail. It is commonly nine to 15 inches long. The biggest largemouth bass known from Michigan weighed 12 pounds and was 25 inches long.

The largemouth bass was originally found east of the Rocky Mountains from Southern Canada to the Gulf of Mexico, including the Southern Great Lakes and central portion of the Mississippi River Watershed. It is now distributed nearly worldwide due to introductions. Northern Michigan is near the northern limit of its natural range, and there is speculation that its presence in the Chain of Lakes is the result of introductions. It can inhabit a wide range of habitats but is found most often in association with soft bottoms, stumps, or extensive growths of emergent or submergent vegetation (like in the small, shallow lakes of the Upper Chain). Its preferred water temperature is about 74° F. It is seldom found deeper than about 20 feet, or the depth to which rooted vegetation grows. The habitats of smallmouth and largemouth bass seldom overlap, even though both are often found in the same water body.

The adult largemouth bass feeds mostly on forage fishes, but also eats crayfish, frogs, and insects. It feeds at all hours, but dawn and dusk are reported to be the most active times. It often moves into very shallow water at night to feed. Feeding and growth do not occur much below 50° F., although it is sometimes caught by ice anglers (more so, interestingly, than smallmouth bass, which generally prefer cooler waters). It usually does not move around extensively, but has a small home territory to which it is thought to return year after year. Its flesh is generally considered good, although some feel it has a muddier flavor and softer texture than other species. It is a favorite species for stocking in small, private ponds.

Spawing occurs in late spring to early summer. Nest building begins when the water temperature hits about 60° F., with egg laying taking place when the temperature warms a few degrees more. This means that spawning can occur as late as early July in the Chain of Lakes. Largemouth bass prefer shallow gravelly or rocky bottoms for spawning, but will successfully utilize almost any type of bottom as long as it is firm and silt-free. The male constructs the nest site, often exposing hard objects such as aquatic plant roots, twigs, and snail shells with a sweeping motion of his fins. The female lays 2,000 to 20,000 eggs. Hatching time is three to seven days. The male fans the eggs gently with his fins to provide fresh, well-oxygenated water. He guards the eggs and schools of fry for several weeks against anything coming within about 20 feet. Interestingly, he does not eat food objects during this time, but simply chews and spits them out some distance away. By the end of summer, the young will have grown to a length of two to three inches. The oldest largemouth bass reported was 16 years old.

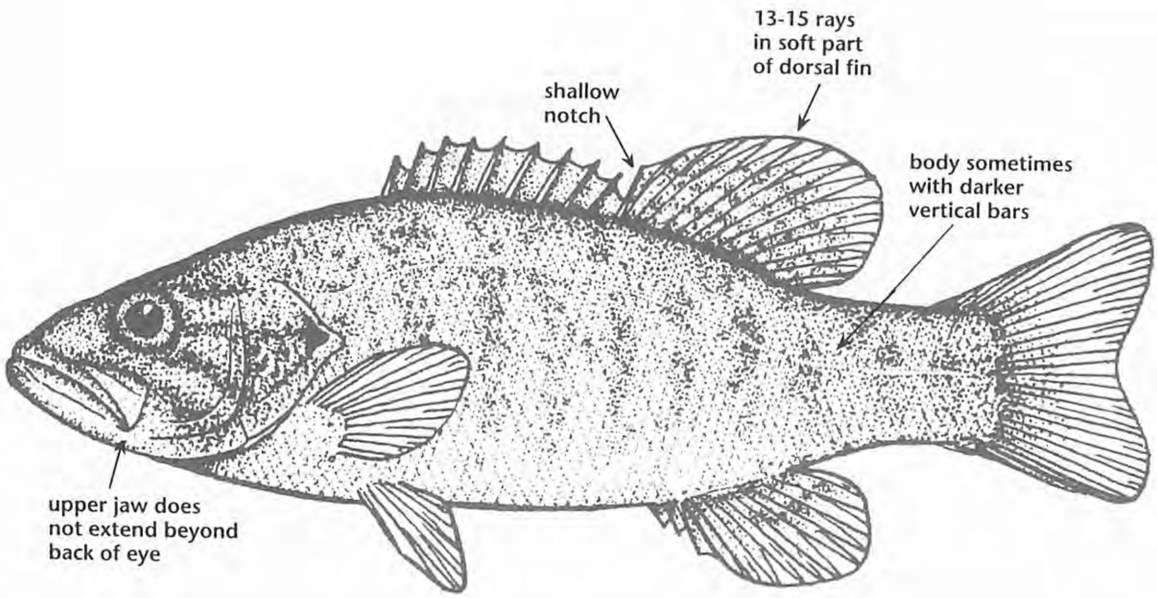
Black crappie *Pomoxis nigromaculatus*
(the scientific names mean sharp gill cover, as opposed to an extended flap in some other sunfishes, and black spotted)

The black crappie's back and upper head is dark green, sometimes with an iridescent glimmer. Its sides are lighter with irregular dark blotches. The underside of its head and body is whitish. It has a yellow-brown eye. Its dorsal, anal, and tail fins are heavily spotted. The average adult length is seven to ten inches, but it can grow to 20 inches and weigh five pounds.

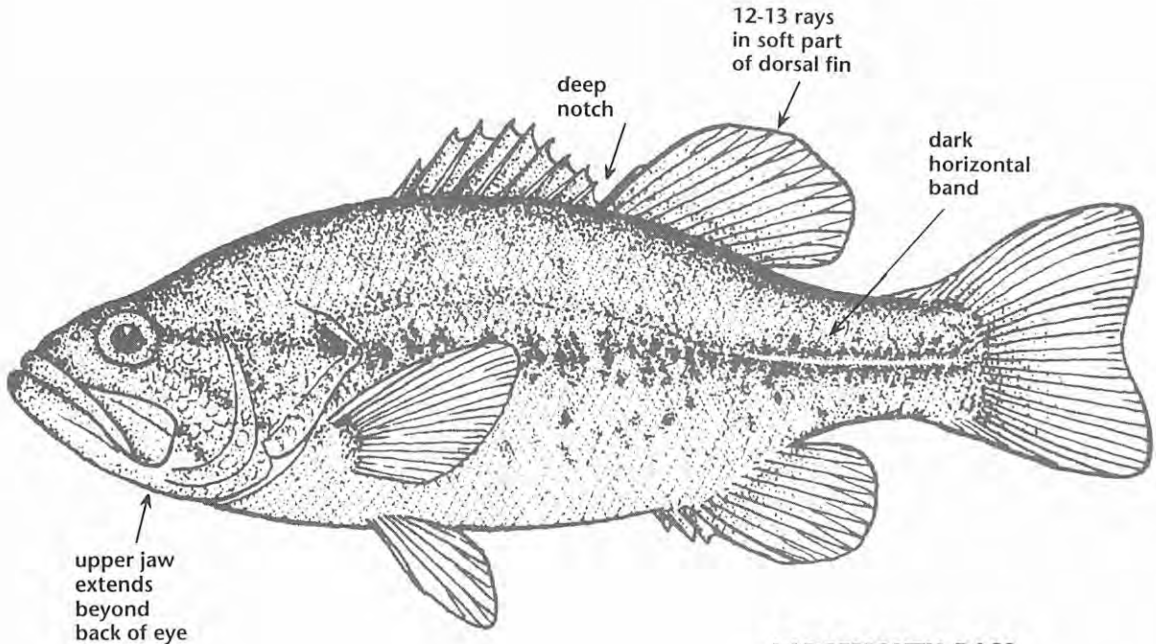
The black crappie's range is fresh and (rarely) brackish waters in Eastern and Central North America, including the Upper St. Lawrence River, Great Lakes, Mississippi River, and Red River Watersheds. However, it has been widely introduced throughout the U.S. It is common in clear or slightly turbid, warm waters of small lakes, bays of large lakes, and large rivers. It prefers vegetated areas.

The black crappie is a carnivore. Newly hatched young eat zooplankton. As it grows, its diet shifts to aquatic insects and other invertebrates. Adults mainly eat a mixture of fish and invertebrates, although they retain the ability to filter zooplankton from the water. Feeding occurs primarily at dusk and dawn, but it also feeds at night. It continues to be active and feed during winter, unlike many other members of the sunfish family. It often feeds in mid-water areas and at the surface. Its preferred temperature is about 72° F. It is a schooling fish. It is utilized as food by larger predatory fish. It is prone to overpopulation and stunting.

Spawning occurs from May to early July, when water temperatures reach 64-68° F. The male constructs a circular nest about nine inches in diameter by sweeping a sand or fine gravel bottom clean with its tail in water one to six feet deep. Nests are spaced four to six feet apart adjacent to vegetation. The female lays up to 180,000 eggs, which stick to the material in the nest. The male guards the nest and young, aggressively attacking intruders until the young begin to feed. The black crappie matures at two to three years of age, and it can live to be seven years old.



SMALLMOUTH BASS
(*Miocropterus dolomieu*)



LARGEMOUTH BASS
(*Miocropterus salmoides*)

Perch Family

The perch family originated in Europe about 100 million years ago, and eventually invaded North America. However, darters evolved, and are still only found, in North America. They exhibit the greatest evolutionary development in this family.

The perch family contains 244 species in 18 genera worldwide, and 130 species in five genera in North America, where they were native only east of the continental divide. There are 19 species in Great Lakes Watershed. In the Chain of Lakes, they are represented by yellow perch, walleye, and four species of darters.

All members of the perch family have long, somewhat flattened bodies which taper toward each end; teeth present on jaws, tongue, and roof of mouth; pelvic fins located forward (almost below the pectoral fins) and with one spine and five soft rays; two separate dorsal fins (the first with spines and the second with soft rays); a small anal fin with one or two spines; a slightly-forked, rounded tail fin; and scales with teeth on the back edge.

Members of the perch family are generally adapted for cool northern waters, where temperatures are below 39° F. for many months of the year. The darters are considered to be the most colorful and beautiful of North American fish, are mostly-stream dwellers, and are especially sensitive to water quality degradation.

Iowa darter *Etheostoma exile*

(the scientific names mean straining mouth and slim or slender)

The Iowa darter has a dark or greenish-brown back and sides, a yellowish belly, eight dark "saddle" marks on its back, nine to 12 vertical bars with small red blotches in between, a black vertical bar under its eye, and brown speckles on its soft dorsal and tail fins (forming wavy vertical lines on the tail). Breeding males become extremely colorful, with dark blue, brick red, and yellow colorings. The average adult length is about two inches, seldom reaching three inches.

Its range is the Upper St. Lawrence River, Great Lakes, Southern Hudson Bay, Upper Mississippi River, and Lake Winnipeg Watersheds. It is found most frequently in clear to slightly turbid, slightly stained waters of small lakes and ponds, streams draining those waters, and medium-sized rivers. It is mostly found in water less than five feet deep over sand or gravel bottoms in association with filamentous algae or other vegetation (except winter, when it is found in deeper water). It is not tolerant of muddy waters, and possibly as a result it has become less common or even disappeared in many parts of its range. However, it can tolerate very low oxygen levels.

The Iowa darter eats zooplankton, aquatic insects, and other small invertebrates. It captures both swimming organisms and those living on the bottom. It is very active during the day, but retreats to hidden crevices at night. When alarmed, it darts quickly for a distance of several feet, sometimes burrowing into the bottom.

Spawning occurs from late April to mid June. The Iowa darter moves into the shallows from deeper water when the temperature reaches about 55° F. The males establish territories several feet in diameter in water four to six inches deep, and chase off other male Iowa darters. Preferred spawning sites are in areas of fibrous plant roots with some aquatic plant growth. The largest, brightest males select the best sites. When ready to spawn, the female moves into a male's territory and positions herself over the exposed roots with the tail lower than the head. The male positions himself over the front of the female, and wraps his tail section around hers. Both vibrate vigorously, and sperm and three to seven eggs are released per spawning act. Females move about and mate with other males, eventually laying up to 900 orange eggs which adhere to roots and vegetation. The male continues to guard the territory, but does not directly care for the eggs. Females are larger than males. The eggs hatch in 18-26 days. Following spawning, it moves back to deeper water (up to 20 feet deep). It can live up to four years.

Johnny darter *Etheostoma nigrum*

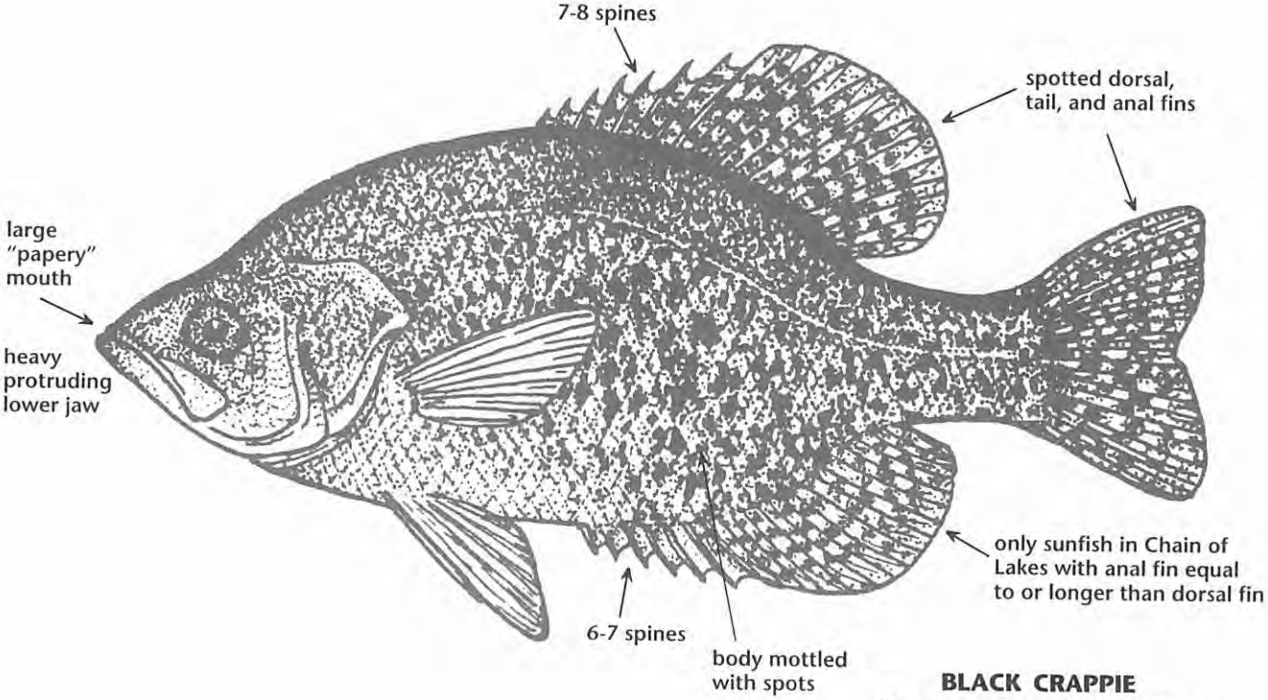
(the scientific names mean straining mouth and black)

The johnny darter has a brown to pale-yellow back; lighter sides; a whitish-yellowish belly; four to seven dark "saddle" marks on its back; W-, J-, and S-shaped brown marks in a line along its side; and a dark stripe from eye to snout. Its dorsal fins usually have rows of brown spots, and its tail fin has wavy vertical brown bands. Breeding males become very dark on the top half. The average adult length is about two inches, but it sometimes reaches a length of three inches.

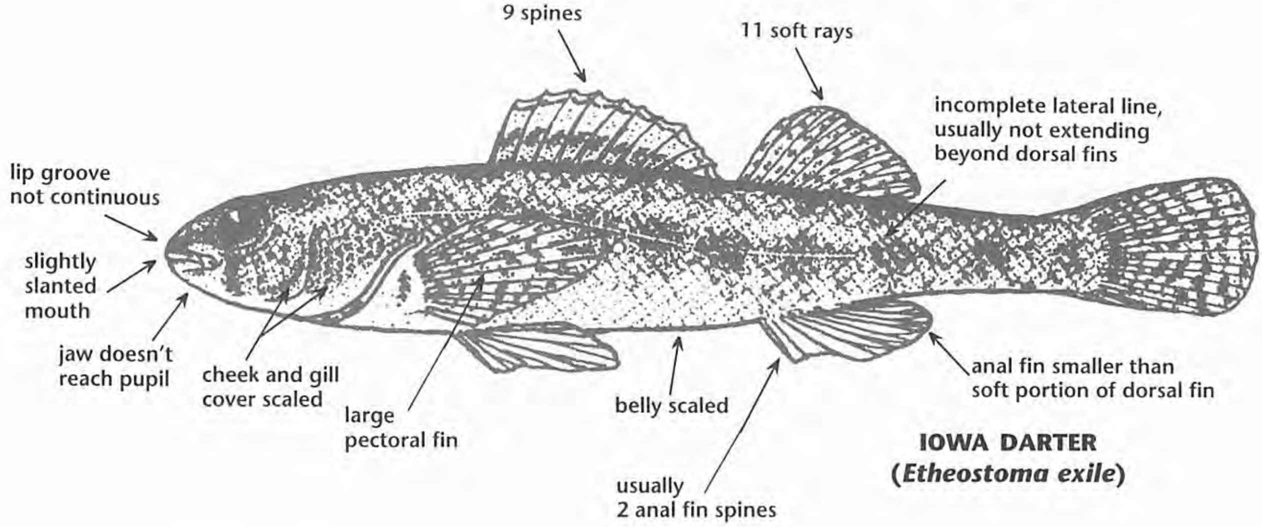
Its range includes the Southwest Hudson Bay, Great Lakes, Upper St. Lawrence River, Upper Mississippi River, Lake Winnipeg, and Hudson River Watersheds, and along the Atlantic Coast from Cape Cod to North Carolina. It is widely distributed in lakes and streams, but it prefers small creeks with sand or gravel bottoms. It tolerates both clear and muddy waters. It is usually found at depths less than two feet, but it has been captured at depths up to 200 feet in Lake Michigan. Because it lives in shallow water, it is often easily observed from shore lying on the bottom with its head up and its body bent slightly to one side. It is the most common darter.

Its food consists of zooplankton, insect larvae, and other small invertebrates. It also ingests muck and sand, probably in the course of feeding on other organisms. It is mostly a sight feeder, feeding mostly during the day and rarely at night. It is utilized as food by a wide range of other fish.

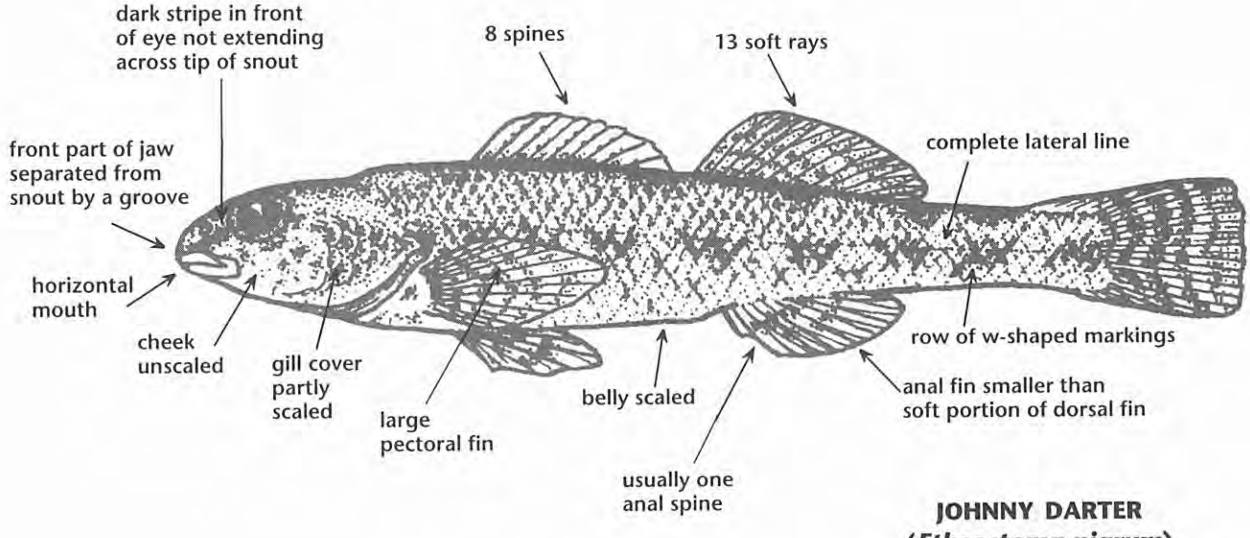
Spawning occurs from May to June when the water reaches about 55° F. Males migrate to protected shallow areas containing rocks, logs, shells, or other objects on which eggs can be laid. Each male establishes a ten-inch diameter territory around a suitable object, driving intruders away (even other species many times its size). It does this by butting and biting fins. The male cleans the underside of the nesting object using his fins. A female joins him in the nest, and both position themselves upside down. The female lays one egg at a time on the underside of the object, which is then fertilized by the male. Females may eventually lay up to 1,000 amber-colored eggs in many different nests. The male guards the eggs, fanning and rubbing them with his fins. The eggs hatch in six to 16 days, depending on temperature.



BLACK CRAPPIE
(*Pomoxis nigromaculatus*)



IOWA DARTER
(*Etheostoma exile*)



JOHNNY DARTER
(*Etheostoma nigrum*)

The johnny darter can live for three years. It is one of the hardiest darters and has been widely used for laboratory studies. It has the unique ability to turn its head quite far without turning its body.

Logperch *Percina caprodes*

(the scientific names mean small perch and pig-like, in reference to the pointed snout)

The logperch is usually yellowish to dark olive on the back, with lighter sides, a whitish belly, and 15 to 25 narrow, dark, zebra-like bands down the sides. The breeding male develops bumps called tubercules on its bottom side. It is the largest darter in the Chain of Lakes. It can reach a length of 5.5 inches, but is usually less than four inches.

The logperch is one of the most common darters. It is found primarily in the Great Lakes, Hudson Bay, and Mississippi River Watersheds. It is common in medium to large streams and in large lakes. In lakes, it seems to be found most along wave-swept shorelines. The logperch is found in diverse river habitats, from fast water to deep, quiet pools. It usually avoids water less than four feet deep except for spawning, and has been collected at depths to 70 feet.

Young logperch feed on a variety of small organisms, but mostly eat zooplankton. Adults eat a wide variety of organisms, including fish eggs, insect larvae and adults, leeches, and small crustaceans and mollusks; as well as algae, plant remains, and organic debris. Logperch are eaten by predatory fish and birds.

The logperch spawns in late spring. Gravel or washed sand is needed for a spawning site. It is the only darter that does not establish a territory or prepare a nest. Instead, logperch spawn in small schools. During spawning, the male clasps onto a single female with his pelvic fins, and the pair vibrate, often helping to bury the eggs. After spawning, the fish move back into deeper water. Females lay only 10 or 20 eggs during each spawning act, but may spawn dozens of times each season. Their eggs may be preyed upon by other male logperch, white sucker, or other species.

The logperch can live for four years. It is active during the day, especially during evening. At night, it remains motionless and partly hidden on the bottom.

Blackside darter *Percina maculata*

(the scientific names mean small perch and spotted)

The blackside darter has a yellow-green back with dark worm-like markings and six to 11 dark "saddle" or "checkerboard" marks. Its sides are yellow with an irregular dark lateral stripe, its belly is whitish, and it has a black bar under its eye. Its spiny dorsal fin is darkly pigmented on the lower half. The average adult length is about 2.8 inches, but it sometimes reaches a length of 4.5 inches.

Its range is the Lake Winnipeg, Lower Great Lakes, and Mississippi River (except the Missouri River system) Watersheds. It is commonly found in quiet areas of medium to large, cool or warm water streams, but it is seldom abundant. It is rarely found in lakes. It prefers clear or slightly turbid water, often associated with vegetation. It has diminished over much of its range from pollution and habitat destruction. It is found more in the mid-water area than other darters. Its preferred water temperature is about 70° F.

Young blackside darters mainly eat zooplankton, and adults mainly eat insect larvae. However, it is probably an opportunistic feeder, consuming any suitably sized food organisms available. It is often found in association with smallmouth bass and rock bass. It becomes inactive at night, lying on the bottom.

Spawning occurs from April to June when the water reaches about 62° F. It spawns in areas of moderate current over coarse sand or fine gravel, one to two feet deep. No nest is built, and the male does not establish a territory. Instead, the male follows a single female, establishing a "moving territory" around her and driving off other males. Eventually, a female will come to rest in a depression in the bottom. A male clasps her by wrapping his body around hers and they vibrate simultaneously, at which time eggs and sperm are deposited. The spawning act is repeated every five to 30 minutes during the daylight hours for several days. A female may lay up to 2,000 colorless eggs which adhere to the bottom. There is no parental care given to the eggs or young. Eggs hatch in about six days. After hatching, the young live among vegetation or plant debris at the stream's margin. It generally matures at the age of two and can live for four years.

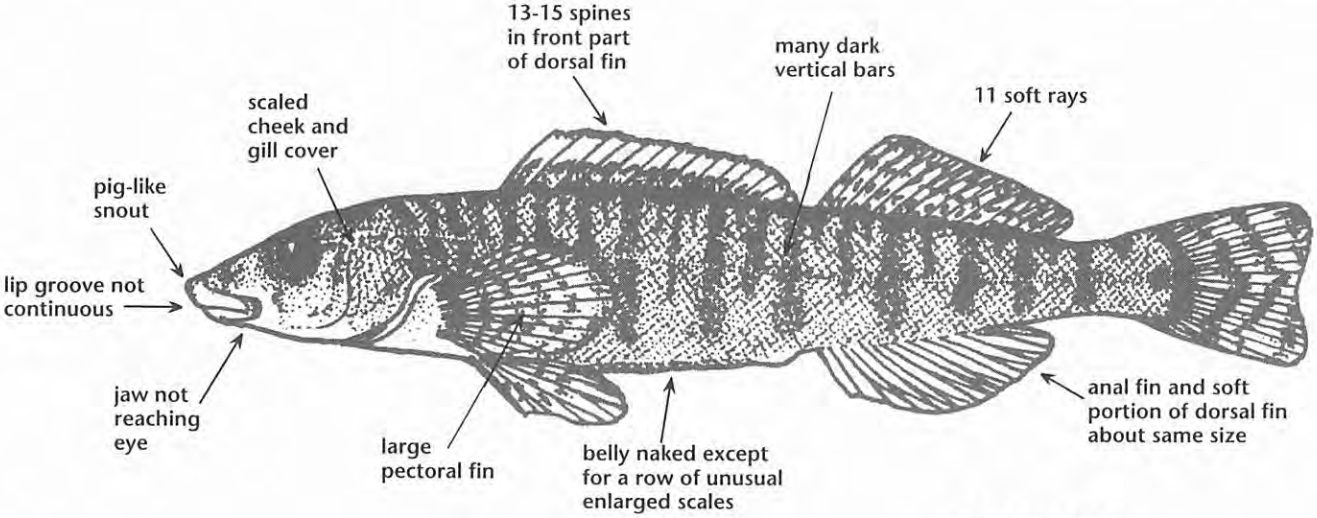
Yellow perch *Perca flavescens*

(the scientific names mean dusky, possibly the ancient common name of the Eurasian perch, and yellow)

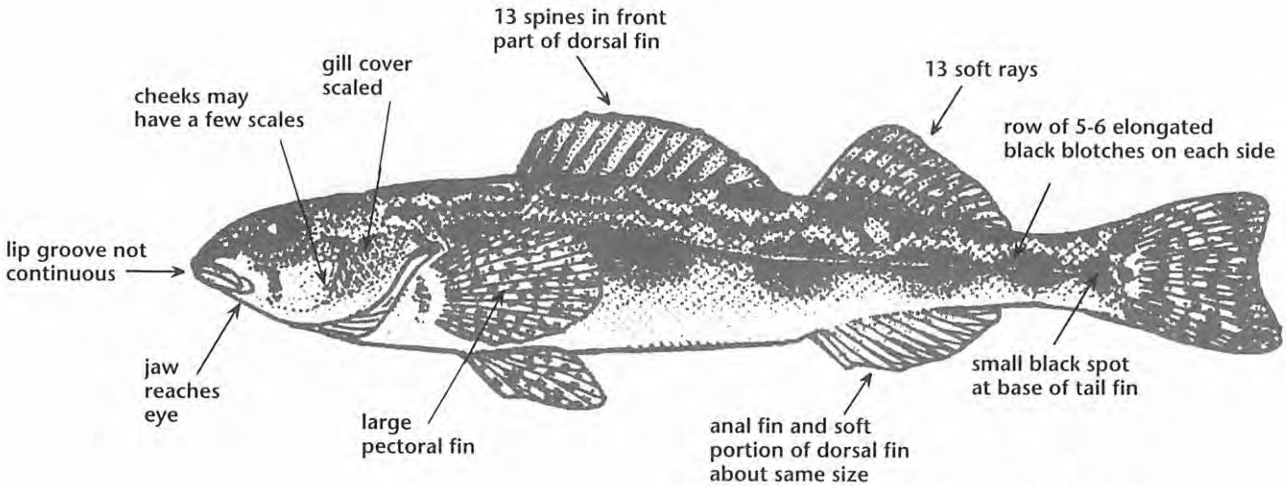
The top of the yellow perch's head and its back are brown or green, its sides are yellow or yellow-green, and it has a whitish belly. There are usually six or seven dark vertical bands on its back and sides. It has yellow or green eyes. Its paired fins are yellowish or reddish. The spiny portion of its dorsal fin has dark pigmentation. The yellow perch is deep-bodied compared to other members of this family, and it is oval, not flattened, in cross section. The average adult length is about five to nine inches, but it has been known to grow to more than four pounds.

The yellow perch is found along the Atlantic Coast from Nova Scotia to Northern Florida, and in the Upper St. Lawrence, Great Lakes, Upper Mississippi River, Southern Hudson Bay, Lake Winnipeg, and Great Slave Lake Watersheds. Some scientists consider it to be the same species as the Eurasian perch, which is found throughout Northern Europe and Asia. It occurs in a wide variety of lake and stream habitats, but it is found most commonly in the shallow waters of lakes with moderate amounts of vegetation, over sand and gravel bottoms. Sometimes it is associated with the bottom, and sometimes it swims suspended in open water. It seems to prefer water about 68° F., but a wide range of temperature preferences have been reported.

After absorbing its yolk-sac, the newly hatched yellow perch eats zooplankton. When it grows to about an inch it begins feeding on aquatic insect larvae. Small fish make up the majority of its diet as an adult, but structures called gill rakers allow yellow perch to filter and feed on zooplankton throughout its life. It has been observed making forays into



LOGPERCH
(*Percina caprodes*)



BLACKSIDE DARTER
(*Percina maculata*)

bottom waters devoid of oxygen for short periods to search for aquatic fly larvae. It generally has two major feeding periods, with the heaviest feeding in the afternoon.

Spawning occurs shortly after ice-out, when the water reaches 45-52° F. This is usually April to early May in inland lakes, but may be as late as late June in the Great Lakes. It does not construct a nest or guard its eggs or young, but rather is a random spawner. Spawning occurs at night, with a female being followed by a group of males. Yellow perch eggs are distinctive. They are contained in a pleated, gelatinous mass called a strand which may be up to seven feet long, four inches wide, and contain tens of thousands of eggs. Strands are usually draped over submerged vegetation or brush in the water. The eggs hatch in eight to 20 days. The newly hatched fry form schools and swim at the surface in open water for three to four weeks, at which time they begin living near the bottom. Males mature at age two, and females at age three. It can live for 13 years.

The yellow perch can tolerate oxygen levels of less than one part per million for extended periods. It often survives winterkill conditions that kill other species. It often forms schools during the daytime when actively feeding, becoming solitary and inactive at night. It almost always bites readily and it is considered one of the finest fish for eating. It has a tendency to become over-abundant, with resulting slow growth. Large lakes with abundant predators seem to have the best growth rates.

Walleye *Stizostedion vitreum*

(the scientific names mean pungent throat and glassy, in reference to its large silvery eyes)

Top of the walleye's head and its back are brownish, greenish, or yellowish; it has lighter sides, and a whitish or yellowish belly. Its sides and back are speckled with dark spots. It has silvery eyes which reflect light well. The soft dorsal fin and tail have spots in rows. The lower tip of the tail fin has a white patch. The average adult length is 14-17 inches, but it has been known to reach a length of 41 inches and a weight of 25 pounds.

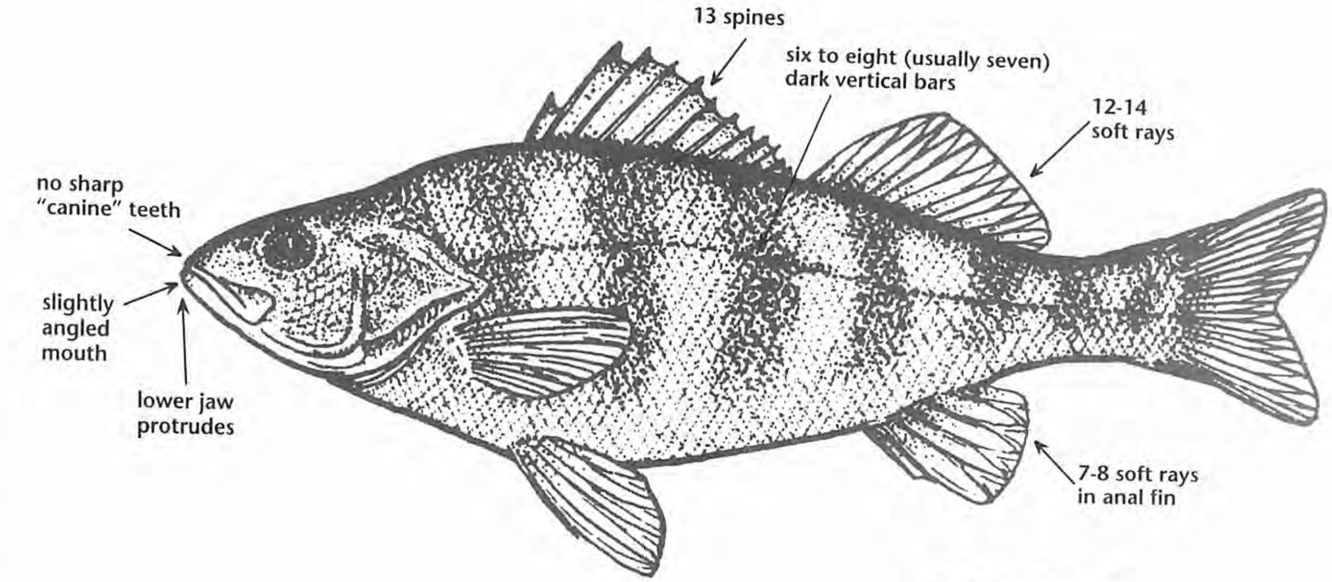
Its range is the St. Lawrence River, Mississippi River, Lower Hudson Bay, Great Lakes, Lake Winnipeg, Great Bear Lake, Great Slave Lake, and Mackenzie River Watersheds, and along the Atlantic Coast from New Hampshire to North Carolina. It has been widely introduced outside its natural range. It is common in many large (>200 acre) lakes and large rivers. It can be found in all types of lakes, but most commonly in clear waters.

Spawning takes place soon after ice-out, when the water temperature is 38-44° F. In inland lakes, this is usually mid April through early May. No nest is built, but the eggs are broadcast over a suitable substrate. In lakes, rocky wave-washed shallows are the preferred sites. Sometimes, spawning occurs in tributaries with gravel bottoms. In some locations, it will utilize flooded wetlands.

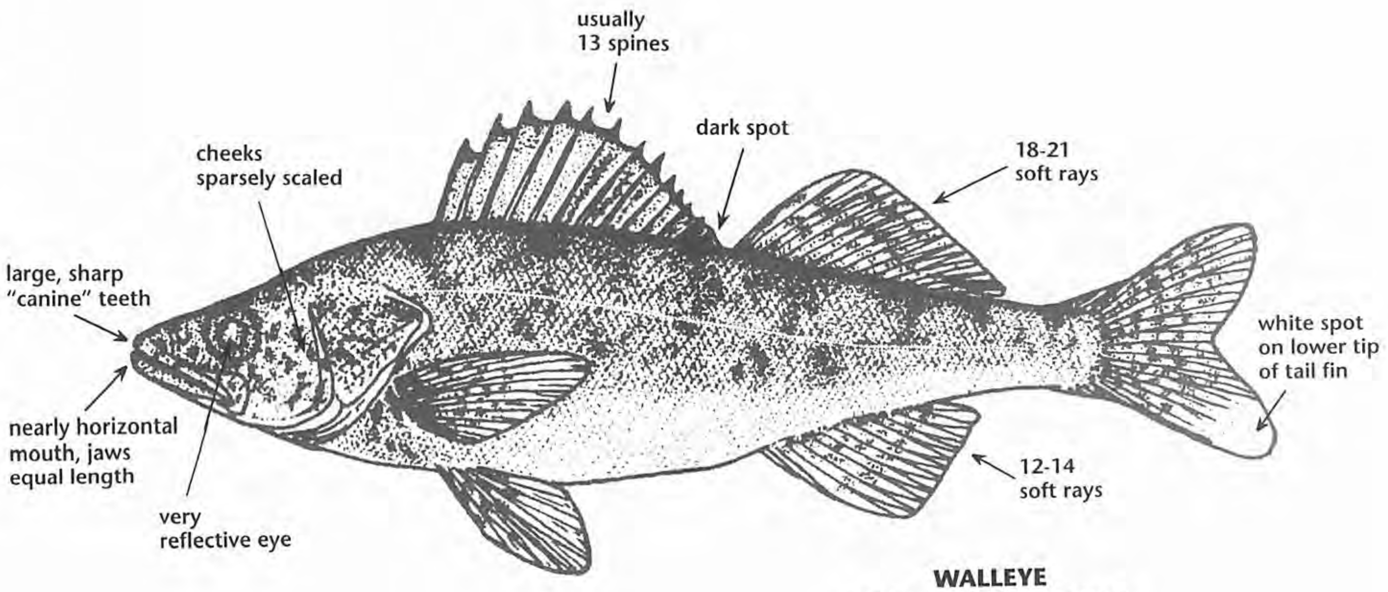
Spawning acts occur at five minute intervals, and several hundred eggs are released during each act. Females may complete their egg laying in one night, but the spawning activity of males is extended longer, resulting in more males than females on the spawning grounds. There is no parental care. Eggs stick to whatever they touch for the first several hours after laying, but if they do not contact anything they become "water hardened" and loose their adhesive qualities. A female may lay several hundred thousand eggs, depending on fish size. Eggs hatch in between one and four weeks, depending on water temperature.

In lakes, walleye fry move into the open, offshore water and feed on zooplankton until they reach a length of an inch or so. At that time, they move to nearshore areas and begin eating insect larvae and small fish, especially the young of yellow perch and white sucker. There, they grow rapidly and may reach a length of five inches by fall. Fish comprise the large majority of the food of adult walleye.

Preferred temperature seems to be about 67° F. The walleye typically retreats to deeper, darker waters during daytime, and moves to the shallower, rocky, weedy areas in the evening. It is active and feeds throughout the winter. It has been observed to travel considerable distances. It congregates in schools or loose aggregations. It is one of the most popular sport species. The walleye's food preference for young largemouth and smallmouth bass seems to have resulted in a decline in these species in a number of lakes where walleye have been introduced. Some waters seem to have tremendous population fluctuations as a result of natural conditions. Females grow larger than males. The average life span is about seven years, with few fish living beyond 12 years (although 18 year old fish have been documented).



YELLOW PERCH
(*Perca flavescens*)



WALLEYE
(*Stizostedion vitreum*)

—CHAPTER FIVE—

Lakes and Streams of the Elk River Chain of Lakes Watershed

The Cedar River's clear, cold waters tumble over ancient logs and flow through a corridor of dense conifer swamps. The Cedar River is the epitome of a Northern Michigan trout stream. It is one of only 47 streams (or only about 2% of all the stream miles in Michigan) to be classified as a blue ribbon trout stream.

A diverse and attractive resource

People are attracted to the beautiful Elk River Chain of Lakes (ERCOL) for a variety of reasons. Its watershed has a great diversity of water resources, from small marshy lakes to some of the largest, deepest, most pristine lakes in the Upper Midwest; and from sluggish warm-water rivers to cold, rushing streams. Historically, one of the biggest attractions has been fishing. A survey of Chain of Lakes riparian households in 1996 by the Tip of the Mitt Watershed Council revealed that someone fishes in 31% of the households.

Basic Types of Lakes and Streams

The Fisheries Division of the Michigan Department of Natural Resources (MDNR), its precursor, the Michigan Department of Conservation (MDOC), or other agencies or researchers have assessed the fish communities of most of the lakes and streams of the Chain numerous times, in some cases dating back to the late 1800s. Most of the surveys have focused on sport fish, so a historical picture of non-sport species is somewhat incomplete. In some instances, accurate identification of non-sport species, especially in older surveys, is questionable. The surveys were usually done with seine, trap, trawl, or gill nets; as well as electroshocking, although visual observation, angler reports, and even spearing were used on occasion. Based on this survey information, the waters of the Chain of Lakes Watershed can be grouped into five basic fish community categories:

1. **Small, shallow, productive lakes**
   These include Beals, Scotts, Six-Mile, St. Clair, Ellsworth, Wilson, Benway, Hanley, and Clam Lakes. These lakes support different types of fish, and more fish per acre, than the waters of the largest, deepest lakes of the Chain. Common species include northern pike, bluegill, black crappie, largemouth and smallmouth bass, yellow perch, and bullhead. Growth rates of fish in the Upper Chain have been found to be variable, being above average in some lakes and in some years, and below average other times and places. Walleyes have historically been present but not abundant in these lakes, but because this is a popular sport species, supplemental stocking has occurred occasionally since the 1930s.

2. **Lakes of moderate size and productivity, and variable depth**
   These include Intermediate, Bellaire, and Skegemog Lakes. Bellaire and Intermediate seem to have historically had the best walleye populations of the Chain. They are also deep enough to support planted trout, and have natural populations of cisco and possibly (at least in the past) some whitefish. Skegemog Lake is renowned for its population of huge Great Lakes musky. They also support many of the same warmwater species commonly found in the small lakes of the Upper Chain, but have fewer aquatic plants, and so have habitat better to the liking of smallmouth rather than largemouth bass.

3. **Large, deep, lakes with low productivity**
   Trout and Elk are the lakes in this category. In summer, their deepest waters are cold and have plenty of oxygen and so contain natural populations of lake trout, whitefish, cisco, burbot, and deepwater sculpin (all species which require cold, well-oxygenated water). Very few inland lakes in Michigan have fish communities like this. In addition, brown and rainbow trout and Atlantic salmon have all been planted to provide additional cold-water sportfishing opportunities. These lakes also have coolwater species like smallmouth bass, yellow perch, and rock bass, but not as abundantly as the other lakes of the Chain. They are managed specifically for the coldwater species.

4. **Trout streams**
   There are more than 200 streams which are tributary to the Chain. All but 24 are quite small and unnamed. Most of these 200 streams have adequate habitat and water quality conditions to support trout, primarily because of the discharge of cold, high quality ground water throughout the summer. The largest of these are the Cedar and Rapid Rivers, which are regionally-renowned trout streams supporting brook, brown, and rainbow trout, as well as non-sport coldwater species such as brook stickleback, mottled sculpin, creek chub, and longnose dace.

5. **Warmwater streams**
   These are mostly the streams that connect the lakes of the Chain, such as the Sinclair, Intermediate, Clam, and Torch Rivers. They are too warm during summer to support trout because their water comes from the warm surface outflow of the lakes (although they may contain trout during the colder times of the year). They generally support a fish community similar to the small lakes of the Upper Chain.

The remainder of this chapter contains more detailed information about the lakes and streams of the ERCOL Watershed. In particular, an attempt was made to summarize the important management activities conducted by the MDNR and MDOC. However, some obscure information may have been overlooked. No attempt was made to distinguish between MDNR or MDOC activities—all are referred to here as MDNR activities. Please refer to Chapter Two for more background information about the descriptive features of lakes and streams. Figure Four depicts the location of the major lakes of the Chain.

Lakes of the Chain and their Connecting Streams

Beals Lake

Beals Lake is the uppermost lake of the Chain. It is also the smallest, both in surface area and volume. It has a very soft organic (mucky) bottom, even close to the shore. Its water is darkly stained by organic compounds draining from swamps upstream.

The lake is oval-shaped, giving it the lowest shoreline development factor (SDF) of any lake in the Chain. Because there are no lakes upstream, its overall watershed and immediate watershed areas are the same.

Marshy vegetation is present around almost the entire perimeter of the lake, but the largest wetland is an extensive alder/hardwood swamp and cattail marsh at the mouth of the lake's inlet. Aquatic plants are present or even abundant throughout the entire lake bottom.

The only public access is a Township-owned lot with an unpaved lane to the water's edge. The marshy, mucky conditions allow launching of only small, light vessels. The only named tributary stream is the Intermediate River, with all of the others being very small and apparently unnamed.

MDNR survey activities have been conducted twice, in 1961 and 1975. A seine or trap net survey of the lake was planned by the MDNR in 1961, but the soft bottom was not conducive to these techniques. Instead, a survey using gill nets was conducted. Rock bass, bluegill, northern pike, bullhead, and white sucker were captured.

A "general" or "biological" lake "survey" or "inventory" was conducted in 1975. (MDNR records use a variety of terms over the years in reference to similar types of surveys). These surveys document features such as vegetation, bottom types, spawning areas, water quality, species of sport and forage fish (generally usually using gill nets and seine hauls), and fishing success. The 1975 findings for fishery characteristics were similar to 1961. Although small, Beals Lake is considered to be good fishing for bluegill, perch, and crappie, but the pike are generally on the small side. Stunting of panfish populations (which is common on many lakes this size) does not seem to be a problem here.

A short stream, less than 1/4 mile long, flows between Beals and Scotts Lakes. The small discharge, coupled with a channel filled with logs and downed trees, makes it unnavigable. This stream has one small tributary called Beals Creek. There is not much elevation drop between Beals and Scotts Lake.

Lake Maps

A map showing water depth contours (called a bathymetric or hydrographic map) and other underwater information is very useful for understanding and fishing a lake. The depth of most lakes in Michigan was mapped by the Michigan Department of Conservation's Institute for Fisheries Research in conjunction with the Civilian Conservation Corps in the 1930s and 1940s. Michigan United Conservation Clubs (MUCC) now holds the copyright to those maps. The lake maps in this chapter were obtained from MUCC and reproduced here with permission. These maps are not to be reproduced without permission, but copies are available from MUCC for $1.00 each. To order maps, or obtain MUCC's Michigan Map Catalog, call 1-800-777-6720. A number of other privately-produced books of lake maps are also available. Sometimes, different maps show different depths. This is probably a reflection on the accuracy of the techniques used at the time of mapping.

Scotts Lake

Oval-shaped Scotts Lake is situated between Beals Lake and Six Mile Lake. Although the hydrographic map shows a small hole extending to about 35 feet deep, extensive searching by Watershed Council staff has revealed a maximum depth of only about 25 feet.

Scotts Lake is the only lake in the Chain without some type of public boat access. There is a parcel of forested State land at the northwest corner of the lake, and plat maps indicate that access to the shoreline by hiking is possible there. However, there are no roads or trails to the shore through this parcel.

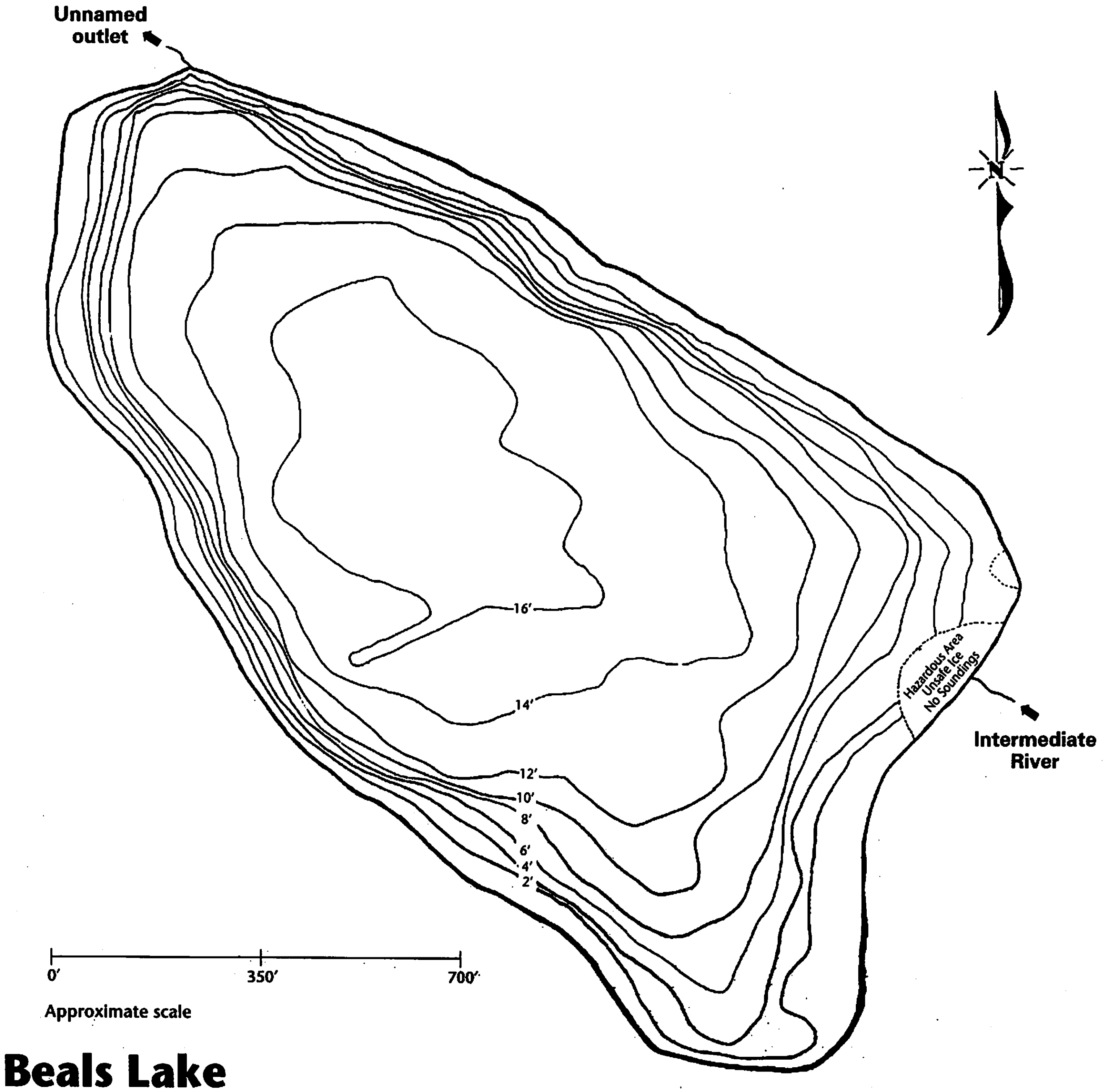
Many of the shoreline wetlands consist of a relatively narrow fringe along the shore. The largest wetlands are swamps (forested wetlands) along the east shore, and around the inlet and outlet streams.

Bottom sediments are very uniform around and throughout the lake—mucky sediments with a lot of woody material near the shore. The mucky sediments are mostly due to the high productivity of the lake and its small size, which precludes the development of more firm, wave-swept shorelines. In Scotts Lake, aquatic plants are present nearshore along the entire perimeter of the lake, and the community composition is quite uniform. None of the nine tributaries are named, although the lake's primary inlet is sometimes referred to as Beal Creek or the Intermediate River (as are several other portions of the connecting rivers between lakes of the Chain).

The MDNR has conducted surveys of the lake in 1959 (aerial survey of ice fishing activity), 1962 (trap net), and 1975 ("general" survey). Species found during the various surveys include black crappie, largemouth bass, northern pike, pumpkinseed sunfish, rock bass, bluegill, white sucker, and bullhead. It is a popular fishing spot for residents and locals who can gain access, and appears to have an aquatic community structure quite similar to Beals Lake.

Dingman River

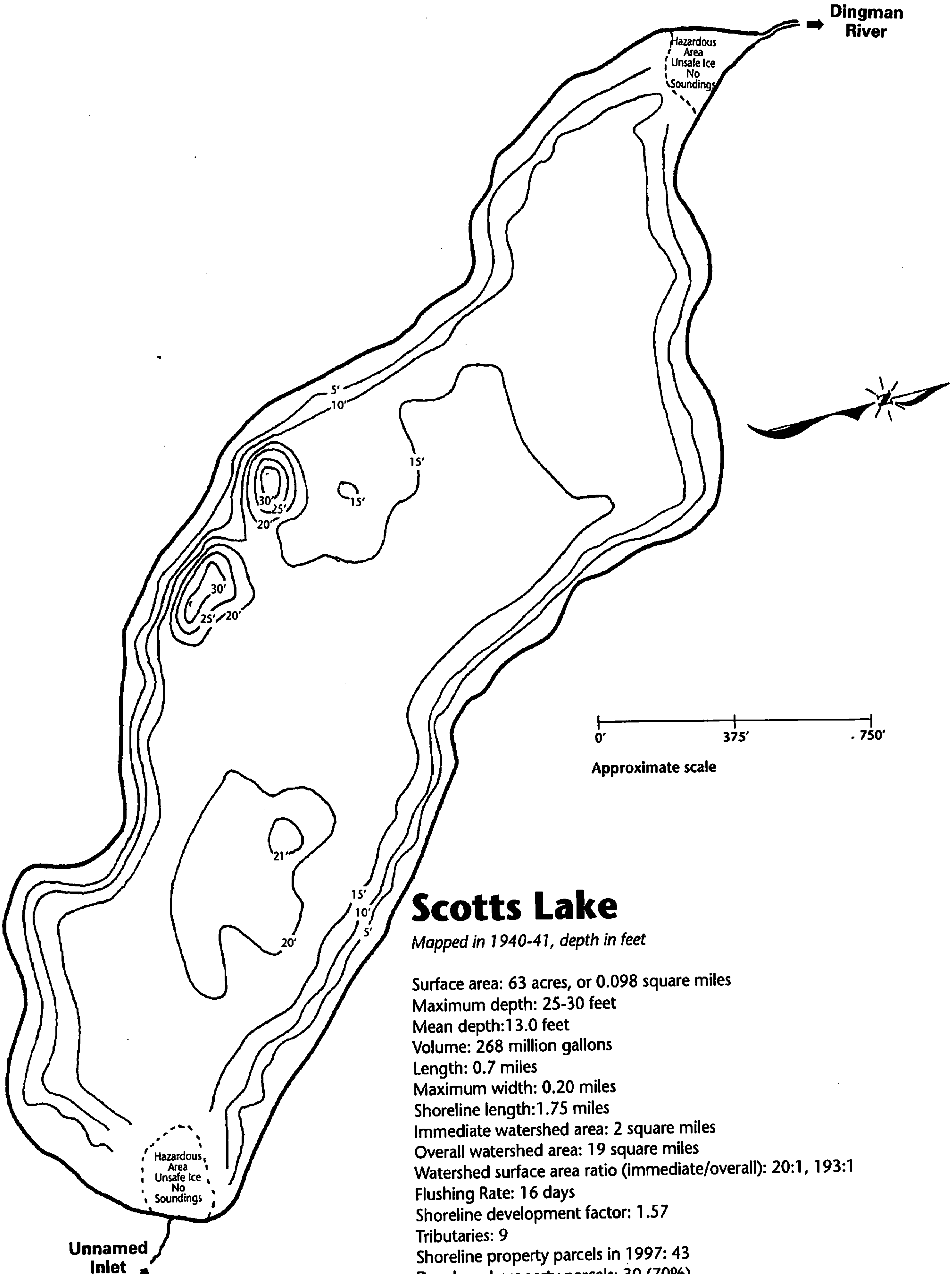
This stream flows about 2.75 miles between Scotts and Six Mile Lake. It is only a little larger than Scotts Lake's inlet stream, and likewise, is not navigable even for small boats. It is a meandering stream. It only drops about 12 feet over its length, a very flat gradient of about four feet per mile. The river is crossed by Dingman School Road about one mile upstream from Six Mile Lake. At this point the average



Beals Lake

Mapped in 1939-40, depth in feet

Surface area: 41 acres, or 0.064 square miles
Maximum depth: 16 feet
Mean depth: 10.2 feet
Volume: 136 million gallons
Length: 0.5 miles
Maximum width: 0.25 miles
Shoreline length: 1.0 mile
Immediate watershed area: 17 square miles
Overall watershed area: 17 square miles
Watershed surface area ratio (immediate/overall): 265:1
Flushing Rate: 10.5 days
Shoreline development factor: 1.1
Tributaries: 6
Shoreline property parcels in 1997: 15
Developed property parcels: 5 (33%)
Extent of wetlands: present along entire shoreline
Public access sites: 1



Scotts Lake

Mapped in 1940-41, depth in feet

Surface area: 63 acres, or 0.098 square miles
Maximum depth: 25-30 feet
Mean depth:13.0 feet
Volume: 268 million gallons
Length: 0.7 miles
Maximum width: 0.20 miles
Shoreline length:1.75 miles
Immediate watershed area: 2 square miles
Overall watershed area: 19 square miles
Watershed surface area ratio (immediate/overall): 20:1, 193:1
Flushing Rate: 16 days
Shoreline development factor: 1.57
Tributaries: 9
Shoreline property parcels in 1997: 43
Developed property parcels: 30 (70%)
Extent of wetlands: present on approximately 36 (83%) of shoreline parcels
Public access sites: 1

What were the lakes of the Chain like before European settlement?

This is an intriguing question, one which probably crosses the minds of those spending much time on or along the lakes. Were they cleaner and clearer? Were there fewer weeds? Even though there are no reliable first-hand accounts, we have gained some insight into this question thanks to a study conducted in the early 1990s on Elk, Intermediate, and Bellaire Lakes.

The study examined sediments deposited on the lake bottom over the last 150 to 200 years for the levels of minerals, organic matter, and the remains of a type of algae called diatoms which have persistent cell walls made of glass. The examination showed clearly that there was increased erosion and sediment deposition associated with logging and settlement in the mid- to late-1800s. In Elk Lake, the increased sedimentation rate abated about 1920, but the rate is still higher than pre-settlement times in Bellaire and Intermediate Lakes.

Based on the kind of diatoms present, it was determined that nutrient levels in Elk and Bellaire increased significantly at the time of logging and settlement, but then gradually declined to levels which are presently close to pre-settlement levels. In Intermediate Lake, nutrient levels were more stable, increasing most in the 1950s. There is some indication that the agriculture which followed the logging was responsible for much of the nutrient enrichment.

Although the species present today still indicate good to excellent water quality, there has been a tremendous increase in the abundance of diatoms since about 1950. This suggests that, while the lake's basic classification status has not changed, all these lakes have experienced a slight but definite increase in the levels of nutrients and productivity compared to pre-settlement times.

The study also found higher levels of zinc and copper in the sediments, probably as a result of air pollution. Sediment "cores" reveal that eight to nine inches of sediments have accumulated over the last 200 years, or a rate of about four inches per century. At this rate, it will take about 30,000 years for a 100-foot deep lake to fill in.

annual flow is 29 cubic feet per second (CFS). According to the United Stated Geological Survey (USGS) topographic map, there are five small tributaries, one of which is named Smith Creek, and the stream corridor is mostly forested wetland (although there is a large marshy area about midway). There are no known fish or water resource surveys of the Dingman River. It is likely that some fish ascend the stream from Six Mile Lake to spawn.

Six Mile Lake

Six Mile Lake is situated between Scotts and St. Clair Lakes. Although relatively long and narrow, its length is four miles, not six as many imply from the name.

A narrow fringe of firm, sandy sediment is found along most of the shoreline out to a depth of one to four feet (depending how exposed the shore is to waves). At that depth, the sediments make a transition to mucky sand, and then to muck at a slightly greater depth. Trunks and branches of trees falling into the water were undoubtedly once common all around the shore, but this woody material (which provides very important habitat for fish and other aquatic organisms) is now found primarily only along undeveloped stretches (having been removed from in front of most cottages to enhance boating and swimming).

A diverse array of aquatic plants (but primarily pondweeds and water milfoil) grows profusely in many areas where the water is shallow enough for sunlight to reach the bottom (generally areas shallower than 12-15 feet), especially along the "dropoff." Pond lillies form dense growths, especially in protected coves, and emergent rushes ring the shore in most places. Although nutrients associated with lakeshore development have probably somewhat increased the abundance of aquatic plants, they were probably always abundant here.

Six Mile Lake has many more tributaries than any other lake in the Chain, although most are very small and apparently unnamed. Named streams include the Dingman River, (the lake's major inlet), and Liscon and Vance Creeks. There is a wide conifer swamp wetland in the vicinity of Liscon Creek and the outlet (the Sinclair River), and marshy/swampy areas are found around the mouth of the Dingman River.

The lake's public access sites include an MDNR boat launch, three township parks, a road right-of way, and an undeveloped wetland at the mouth of the Dingman River owned by Antrim County.

The MDNR has surveyed the lake five times: in 1948 (trap net), 1951 ("general"), 1959 (aerial survey of ice fishing activity), 1968 (gill net and electrofishing), and 1999 (gill, trap and fyke net).

Fish species identified during the various surveys include smallmouth and largemouth bass, northern pike, Great Lakes muskellunge, rock bass, black crappie, yellow perch, bluegill, pumpkinseed sunfish, longnose gar, brown bullhead, walleye, and white sucker. Walleye were planted in 1979, and again from 1985 to 1998 on a three-year rotation. In late June, 1951, water sampling found only 0.4 PPM of D.O and 61° F. water at a depth of 30 feet.

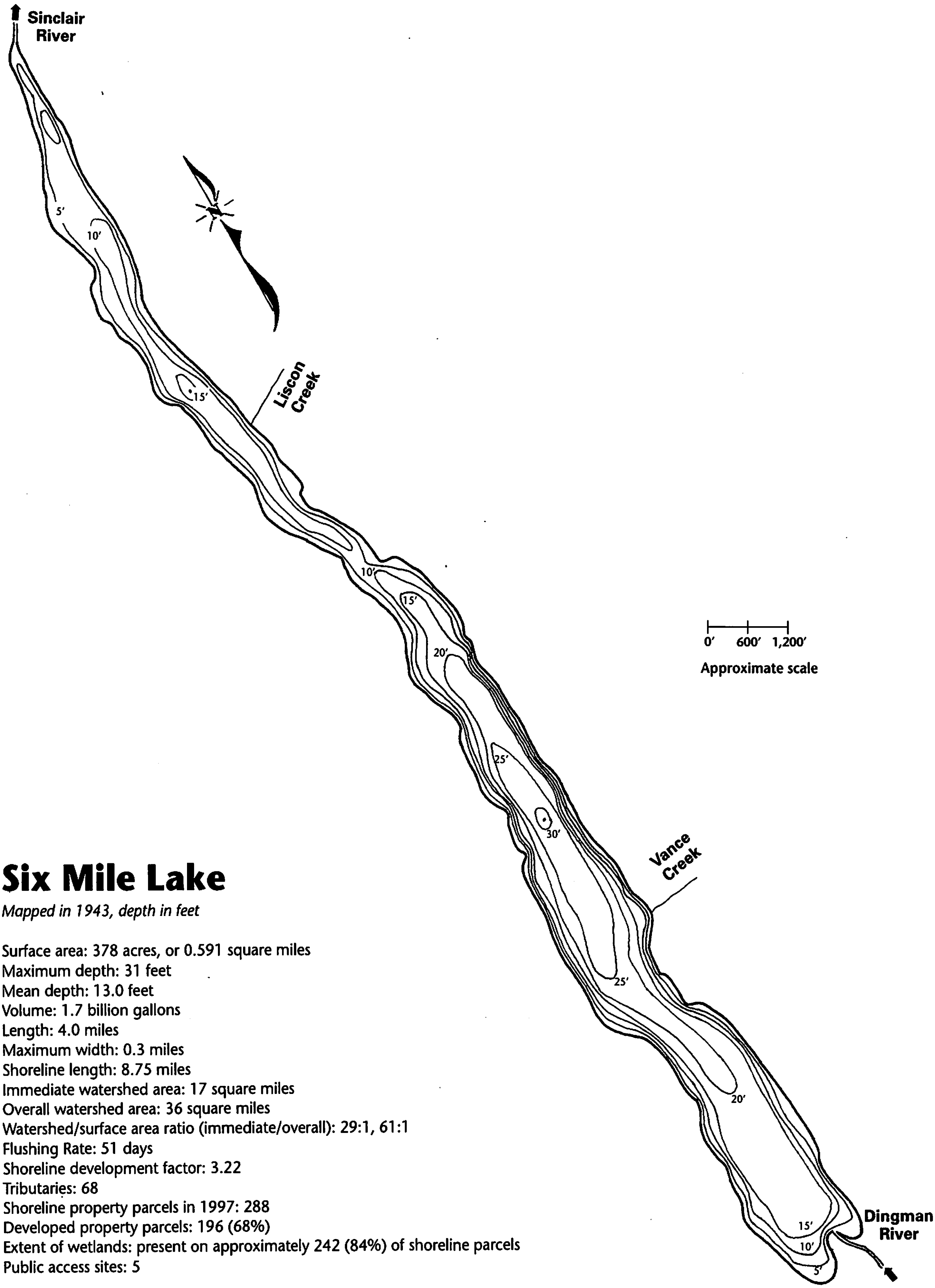
In 1968, fish growth rates were found to be mostly below state averages. However, the 1999 survey found that for the most part fish populations in Six Mile Lake were in very good shape, with most species growing above state averages and showing good size distribution. Naturally produced walleye (either from Six Mile Lake or migrants from lower in the Chain) are present in addition to stocked fish. However, there was a large population of small pike (mostly below the 24-inch size limit), which seems to be preying heavily on the yellow perch. As of April 1, 2001,

PHYSICAL FEATURES OF LAKES IN THE ELK RIVER CHAIN OF LAKES[1]

LAKE NAME	SURFACE AREA (acres/sq miles)	MAX. DEPTH (feet)	MEAN DEPTH (feet)	VOLUME (gallons)	LENGTH (miles)	MAX. WIDTH (miles)	SHORELINE LENGTH (miles)	IMMEDIATE WATERSHED AREA (sq.miles)	OVERALL WATERSHED AREA (sq.miles)	WATERSHED AREA TO SURFACE AREA RATIO (immediate/overall)	FLUSHING RATE[2]	SHORELINE DEVELOPMENT FACTOR
Beals	41/0.064	16	10.2	136,000,000	0.50	0.25	1.00	17	17	265/265	10.5 days	1.10
Scotts	63/0.098	25-30[3]	13.0	268,000,000	0.70	0.20	1.75	2	19	20/193	16 days	1.57
Six Mile	378/0.591	31	13.0	1,700,000,000	4.00	0.30	8.75	17	36	29/61	51 days	3.22
St. Clair	91/0.142	32	10.0	212,000,000	1.25	0.20	2.30	7	43	49/302	5.2 days	1.72
Ellsworth	120/0.188	42	17.0	668,000,000	1.60	0.20	3.50	14	57	75/304	15.9 days	2.29
Wilson	106/0.166	48	11.5	396,000,000	1.40	0.15	4.60	20	77	121/465	7.9 days	3.19
Benway	131/0.205	42	15.0	645,000,000	1.10	0.25	2.70	7	84	34/410	10.6 days	1.69
Hanley	93/0.145	27	10.6	322,000,000	1.50	0.20	3.50	5	89	34/612	5 days	2.59
Intermediate	1,520/2.38	80[3]	28.0	16,000,000,000	8.00	0.75	14.70	26	114	11/48	173 days	2.69
Bellaire	1,793/2.80	95	42.0	25,000,000,000	4.50	1.50	11.50	42	161	15/57	146 days	1.94
Clam	439/0.686	27	13.0	1,800,000,000	3.25	0.40	8.50	13	199	19/290	8.2 days	2.89
Torch	18,473/28.86	302[4]	140.0	362,000,000,000 (0.78 cu.mile)	18.00	2.50	41.40	76	275	2.6/9.5	6.9 years	2.17
Skegemog	2,560/4.00	29	12.4	10,300,000,000	3.70	1.80	11.00	187	462	47/116	24 days	1.55
Elk	7,730/12.08	192	71.0	180,000,000,000 (0.16 cu.mile)	9.00	2.00	26.00	43	505	3.6/42	0.99 years	2.11

1. Primarily from MDNR, MDEQ, and Watershed Council data and calculations
2. Based on estimated annual normalized flow of outlet stream
3. Based on Watershed Council monitoring data
4. From *Navigational Charts of the Elk River Chain of Lakes*

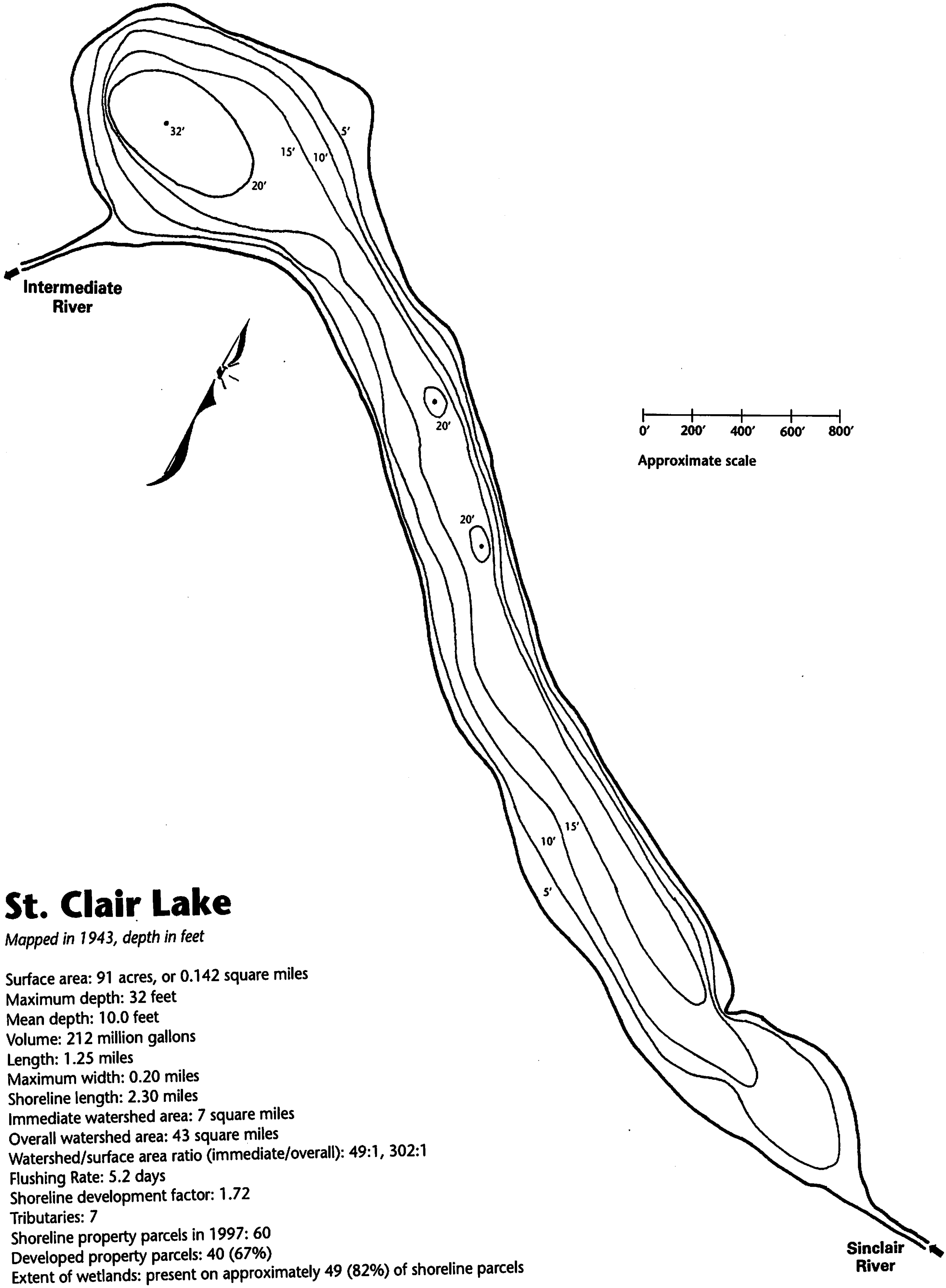
Figure 34 - Physical Features of Lakes and Streams in the Elk River Chain of Lakes. Please refer to Chapter Two for descriptions of these parameters.



Six Mile Lake

Mapped in 1943, depth in feet

Surface area: 378 acres, or 0.591 square miles
Maximum depth: 31 feet
Mean depth: 13.0 feet
Volume: 1.7 billion gallons
Length: 4.0 miles
Maximum width: 0.3 miles
Shoreline length: 8.75 miles
Immediate watershed area: 17 square miles
Overall watershed area: 36 square miles
Watershed/surface area ratio (immediate/overall): 29:1, 61:1
Flushing Rate: 51 days
Shoreline development factor: 3.22
Tributaries: 68
Shoreline property parcels in 1997: 288
Developed property parcels: 196 (68%)
Extent of wetlands: present on approximately 242 (84%) of shoreline parcels
Public access sites: 5



St. Clair Lake

Mapped in 1943, depth in feet

Surface area: 91 acres, or 0.142 square miles
Maximum depth: 32 feet
Mean depth: 10.0 feet
Volume: 212 million gallons
Length: 1.25 miles
Maximum width: 0.20 miles
Shoreline length: 2.30 miles
Immediate watershed area: 7 square miles
Overall watershed area: 43 square miles
Watershed/surface area ratio (immediate/overall): 49:1, 302:1
Flushing Rate: 5.2 days
Shoreline development factor: 1.72
Tributaries: 7
Shoreline property parcels in 1997: 60
Developed property parcels: 40 (67%)
Extent of wetlands: present on approximately 49 (82%) of shoreline parcels
Public access sites: 1

there will no longer be a size limit on Six Mile Lake's pike in hopes of encouraging better growth. Northern pike, walleye, largemouth bass, yellow perch, and bluegills are reported to be the mainstay of the sport fishery in Six Mile Lake.

Sinclair River

The Sinclair River flows about 0.9 mile between Six Mile and St. Clair Lakes. There is very little elevation drop. This stream is noticeably much larger than Six Mile Lake's inlet, the Dingman River. The difference is attributable to the large amount of ground water which flows into Six Mile Lake and its large number of tributaries. The interconnecting streams of the Chain are navigable from this point downstream for small, nonmotorized vessels as well as small motorboats.

Wide wetlands, including marshes, and hardwood and conifer swamps, are present all along the river. There is one tributary stream, named St. Clair Creek.

Firm sand sediments are present throughout most of center of the river's channel, but the channel margins are mucky. Submergent aquatic plants grow throughout the river, with beds of emergent and floating-leaved plants on the margins. This is a great place to paddle along slowly on a still morning and watch fish through the clear waters and other wildlife along the marshy margins.

No road crosses the Sinclair River. There are ten properties with frontage on the river, none of which are developed. As of 1999, seven of the parcels were owned by the Grand Traverse Regional Land Conservancy or the Little Traverse Conservancy and are part of the St. Clair-Six Mile Lake Natural Area Project. All of these properties are open to the public. One parcel has a short trail, boardwalk, and observation platform overlooking the beautiful riverside marshes; and a site where small boats may be launched.

St. Clair Lake

St.Clair Lake is situated between Six Mile Lake and Ellsworth Lake. MDNR records indicate that it was once known as Campbell Lake. Like most other lakes of the Upper Chain, it is relatively long and narrow.

Bottom sediments and the occurrence of aquatic plants are very similar to that described for Six Mile Lake. Exceptions to this generally exist around the inlet of the Sinclair River, where firm sand sediments are absent. Gravelly sediments are found in two small locations, possibly from past filling activities associated with shoreline development.

The only named tributary is the lake's inlet, the Sinclair River. The only public access is an MDNR boat launch on the south shore.

The MDNR has surveyed St. Clair Lake four times: 1959 (aerial survey of ice fishing activity), 1957 ("general"), 1966 (fish growth analysis), and 1968 (gill net and electrofishing).

Species present during the various surveys include rock bass, black crappie, northern pike, smallmouth and largemouth bass, bluegill, yellow perch, pumpkinseed sunfish, green sunfish, and mimic shiner.

A 1943 memo in MDNR files reported good fishing in St. Clair Lake for black crappie, yellow perch, bluegill,

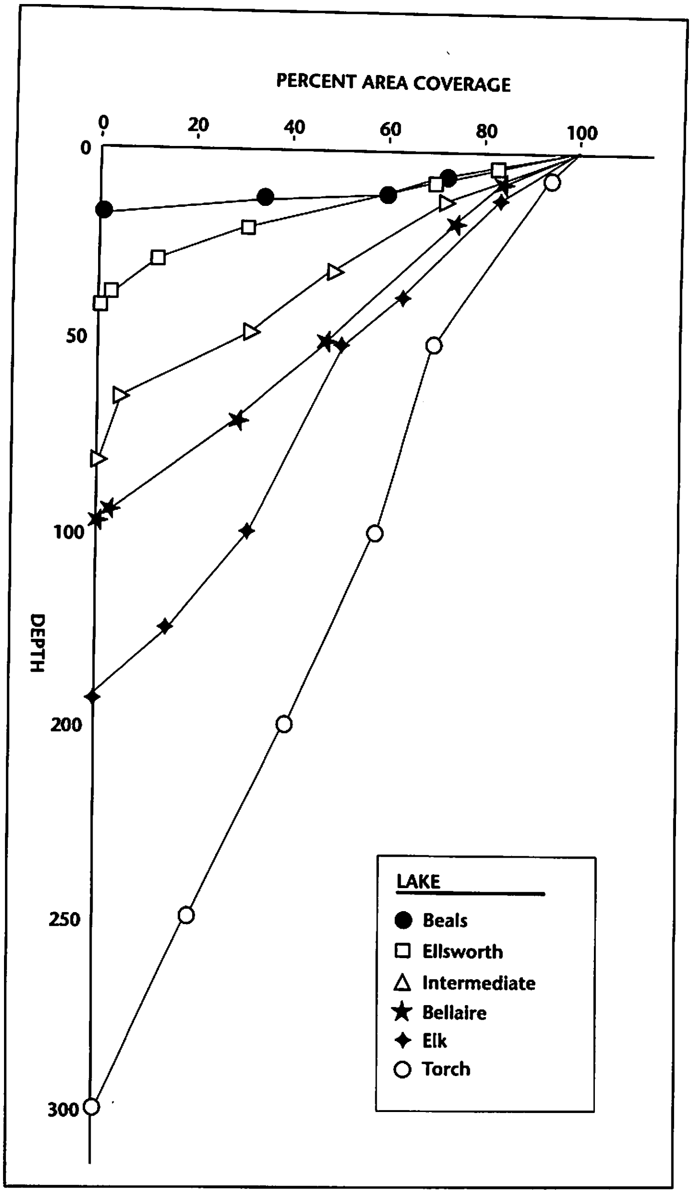


Figure 35 - Hypsographic curves of selected lakes of the Chain. A hypsographic, or depth-area, curve is a graphic representation of the relationship between the surface area of a lake and its depth. Although not meant to represent the shape of the basin in cross-sectional profile, when compared with other lake basins it can provide a comparison of relative basin shape (i.e saucer-, cone-, or trench-shaped).

northern pike, and largemouth and smallmouth bass. Water analysis in the summer of 1957 showed 3.4 PPM of D.O. at 20 feet, dropping to only 0.3 PPM at 30 feet. In 1968, growth rates of fish were mostly below state averages.

Intermediate River Between St. Clair and Ellsworth Lakes

This short river segment is only 0.3 mile long. The river flows under Pleasant Hill Road through an eight-foot diameter corrugated metal pipe culvert. The river's average annual flow at this point is about 63 CFS. It is navigable by power boats up to 16 feet long, except when the water is extremely high or low. There is not much elevation loss between St. Clair and Ellsworth Lakes.

The Village of Ellsworth's Wooden Shoe Park is located on the east bank of the river, near its mouth. The public can also access the stream from the road crossing. There is one tributary, Skinner Creek, which enters from the northwest. Firm sand sediments are present throughout most of the channel, with the margins being mucky. A shallow sandbar is present at the river's mouth. The source of this sand is probably Skinner Creek.

Ellsworth Lake

Ellsworth Lake is situated between St. Clair Lake and Wilson Lake. Bottom sediments and the occurrence of aquatic plants are very similar to that described for Six Mile Lake.

Two shale pits on either side of the lake are plainly visible from the water and offer a revealing glimpse of the subsurface geology of the lake's immediate watershed—about 30 feet of reddish glacial till on top of green-grey Ellsworth shale (see Figure Six, Chapter One).

Most of the west shore of the lake is undeveloped because of a railroad right-of way which was located there until recently. Public access sites include an MDNR boat launch, a county park, and rights-of-way along Rushton Road. There are signs of accelerated erosion at Wooden Shoe Park, probably due to the large volume of pedestrian traffic. Except for the lake's inlet (the Intermediate River), all of the other tributaries are very small and apparently unnamed.

The MDNR has conducted surveys on Ellsworth Lake six times: 1943 ("general"), 1948 ("general"), 1957 ("general"), 1968 (gill net), and 1985 and 1986 ("general" survey and collection of fish for contaminant analysis).

Species which have been reported include black, yellow, and brown bullhead; longnose gar; longear sunfish; white sucker; bluegill; yellow perch; northern pike; black crappie; smallmouth and largemouth bass; rock bass; pumpkinseed sunfish; and walleye.

In 1957 there was concern about waste from a cannery in Ellsworth causing extreme oxygen depletion. A late-July sample found 3 PPM of D.O. at 17 feet, and virtually none below 20 feet. The 1968 survey was based on reports of poor fishing. Except for bass, most species had below average growth rates. In the 1970s contamination of soil, ground water, and lake sediments with metals and other toxic substances was discovered associated with an abandoned factory site in Ellsworth. At one time it was the highest-ranking ground water contamination site in Michigan. Fish and other aquatic life were found to contain some contaminants, but in relatively low levels. The site has since apparently been successfully cleaned up by the Michigan Department of Environmental Quality.

Lake Associations

It is common for a group of waterfront property owners (riparians) and lake users to band together into an association. Lake associations can be either informal or formal, with scheduled meetings, officers, by-laws, and dues. A lake association's mission is generally both social and functional. Lake associations can effectively take on water resource protection issues that are too big for a single individual. Fisheries management is often one of the issues of greatest interest.

Seven of the lakes of the Chain have one or more associations which have formed to, among other things, protect water quality and properly manage water resources.

Six Mile Lake Association (organized in 1992)
P.O. Box 421, Central Lake, MI 49622

Intermediate Lake Association (organized in 1998)
P.O. Box 795, Central Lake, MI 49615

Three Lakes Association (organized in 1966, serving Torch, Clam, and Bellaire Lakes)
P.O. Box 353, Alden, MI 49612

Torch Lake Protection Alliance (organized in 1997)
7730 S. East Torch Lake Drive, Alden, MI 49612

Elk-Skegemog Lake Association (organized in 1950)
P.O. Box 8, Elk Rapids, MI 49629

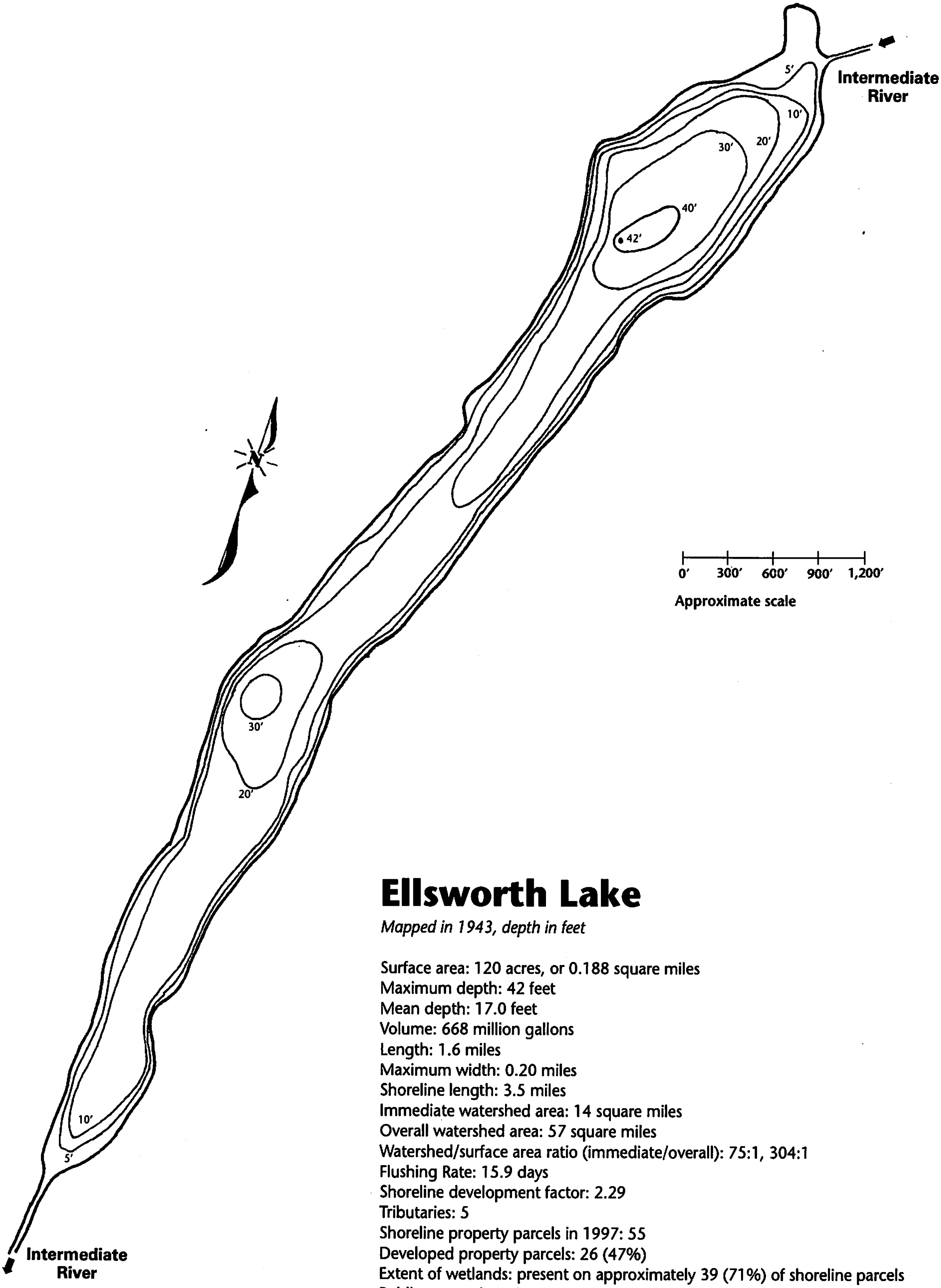
The Tip of the Mitt Watershed Council formed in 1979 as an "umbrella" organization for area lake associations, and continues to work closely with all the lake associations of the Chain. If you live on or use one of these lakes, consider joining the association for that lake to lend your support to protect water quality and fisheries resources.

Intermediate River Between Ellsworth and Wilson Lakes

This stretch of the Intermediate River is only about 0.25 mile long. There is very little elevation loss over this stretch. The river is crossed by Clay Pit Road (a gravel road) via a narrow old bridge. There are 13 property parcels along this stretch of river, seven of which are developed. Wetlands are present along all 13. The bridge crossing represents the only public access. There is one small, unnamed tributary. Firm sand sediments are present throughout most of the channel, but the margins are mucky. There are some rocky or gravelly areas near the bridge, probably having been placed as roadbed fill material. As with many of the interconnecting rivers, this segment was deepened by dredging many years ago, probably to facilitate log drives. The dredge spoils are visible as a narrow upland ridge on the east bank of the river.

Wilson Lake

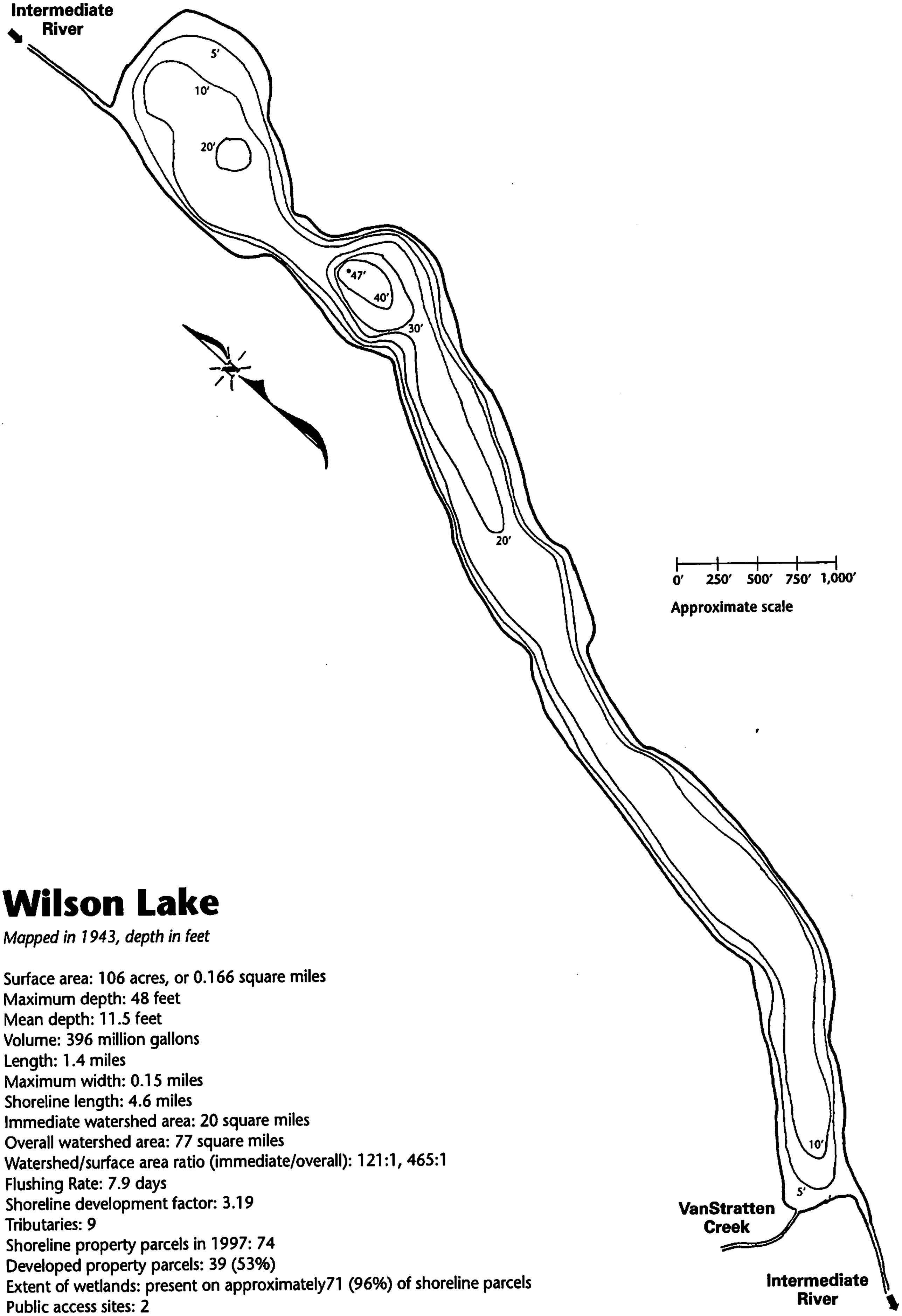
Wilson Lake is situated between Ellsworth Lake and Benway Lake. Most of the west shore of the lake is undeveloped because of a railroad right-of-way which was located there until recently. An MDNR boat launch and a small undeveloped parcel owned by Antrim County are the two public accesses on Wilson Lake. Bottom sediments and the occurrence of aquatic plants are very similar to those



Ellsworth Lake

Mapped in 1943, depth in feet

Surface area: 120 acres, or 0.188 square miles
Maximum depth: 42 feet
Mean depth: 17.0 feet
Volume: 668 million gallons
Length: 1.6 miles
Maximum width: 0.20 miles
Shoreline length: 3.5 miles
Immediate watershed area: 14 square miles
Overall watershed area: 57 square miles
Watershed/surface area ratio (immediate/overall): 75:1, 304:1
Flushing Rate: 15.9 days
Shoreline development factor: 2.29
Tributaries: 5
Shoreline property parcels in 1997: 55
Developed property parcels: 26 (47%)
Extent of wetlands: present on approximately 39 (71%) of shoreline parcels
Public access sites: 4



Wilson Lake

Mapped in 1943, depth in feet

Surface area: 106 acres, or 0.166 square miles
Maximum depth: 48 feet
Mean depth: 11.5 feet
Volume: 396 million gallons
Length: 1.4 miles
Maximum width: 0.15 miles
Shoreline length: 4.6 miles
Immediate watershed area: 20 square miles
Overall watershed area: 77 square miles
Watershed/surface area ratio (immediate/overall): 121:1, 465:1
Flushing Rate: 7.9 days
Shoreline development factor: 3.19
Tributaries: 9
Shoreline property parcels in 1997: 74
Developed property parcels: 39 (53%)
Extent of wetlands: present on approximately71 (96%) of shoreline parcels
Public access sites: 2

described for Six Mile Lake. Named tributaries include the Intermediate River (Wilson Lake's major inlet from Ellsworth Lake), and Von Stratten Creek (in the southwest corner of the lake). A pronounced sand delta is evident at Von Stratten Creek, a result of the creek's sand bedload.

The MDNR has surveyed Wilson Lake two times: 1957 (aerial survey of ice fishing activity and gill net survey), and 1968 (gill net and electroshocking). A file note from 1957 mentions that spawning grounds for bass and sunfish are located along the western shore. The 1968 survey was conducted following reports of poor fishing.

Intermediate River Between Wilson and Benway Lake

This is another short river segment, with the distance between the lakes being only 0.3 mile. No roads cross the river. There are four shoreline properties, and no development along the river itself (although one of the properties also lies partly on Benway Lake at the river mouth, and a house is located there). There is no direct public access to the lakeshore, although the MDNR access site on Wilson Lake is just upstream from the head of the river. A wide swamp is present all along the river, and there are no tributaries. Typical of other segments of interconnecting rivers throughout the Upper Chain, firm sand sediments are present throughout the center portion of the channel, with mucky margins.

Benway Lake

Benway Lake is situated between Wilson Lake and Hanley Lake. Bottom sediments and the occurrence of aquatic plants are very similar to those described for Six Mile Lake. Most of the west shore of the lake is undeveloped because of a railroad right-of-way which was located in some areas until recently, and because of extensive wetlands. Although Benway Lake has no public access along its shore, there are two public accesses nearby—on the south end of Wilson Lake and along a bridge crossing on the Green River just downstream of Benway Lake. Named tributaries include the Intermediate River (Benway Lake's major inlet from Wilson Lake), and Ogletree Creek, which enters the lake just upstream from the outlet, on the west shore. A pronounced sand delta is evident at Ogletree Creek, a result of the creek's sand bedload.

The MDNR has conducted two surveys on Benway Lake: in 1957 ("general") and 1968 (gill net and electrofishing). File memos in 1943 and 1949 reported Benway to be a good fishing lake, with northern pike, black crappie, and yellow perch dominating the catch.

The 1957 survey found yellow bullhead, yellow perch, a few smallmouth bass and walleye, Iowa and johnny darter, bluntnose minnow, and common shiner. No D.O. was found below 30 feet by mid-July.

Reports of poor fishing prompted the 1968 survey. Largemouth bass (to 15"), bluegill (to 7"), yellow perch (to 12"), cisco (to 13"), black crappie (to 7"), rock bass (to 8"), pumpkinseed sunfish (to 5.5"), northern pike (to 28"), longnose gar, white sucker, and black bullhead were collected. Growth rates were generally at or slightly above state averages. Conclusions were that the lake supported a good warmwater fish population. Bass and/or bluegill were stocked between 1937 and 1943.

Green River

The relatively long (0.6 mile) stretch of river between Benway and Hanley Lakes is called the Green River. The river is crossed by Mohrman Bridge Road, and this point offers the only public access (although there are no paths or launching facilities). A high, wide bridge with a paved surface was recently constructed here to replace an older structure. The river's average annual flow at the bridge is about 94 CFS.

The Green River has 24 properties. Nineteen of them are developed, all on the east bank where a sloping upland is present. Fourteen of the waterfront properties are at least partly wetland. The river's west bank is a wide swamp.

The Green River has a large meander bend known as the Devil's Elbow, where water is eight to ten feet deep. The river bed is mostly firm sand, with mucky sand or mucky margins. There is a very shallow sandbar just downstream from the bridge. However, there are a few apparently natural rocky/gravelly areas, as well as rocks and gravel in the vicinity of the bridge. Aquatic plants are sparse in the Green River.

Hanley Lake

Like most of the small lakes of the Upper Chain, Hanley's deepest spot is at the south end near the outlet. This may be because the north (inlet) parts of these lake basins were filled by river-bourne sediments, possibly in post-glacial times. Hanley Lake's flushing rate of only 5 days is the fastest of any lake in the Chain. Bottom sediments and the occurrence of aquatic plants are very similar to that described for Six Mile Lake. The only public access is an unimproved street easement in the Village of Central Lake. The only named tributary stream is the Green River (Hanley Lake's major inlet from Benway Lake). All of the other tributaries are very small and apparently unnamed.

The MDNR has conducted surveys 10 times on Hanley Lake: a yearly creel census by conservation officers from 1942-1949, 1957 ("general"), and 1968 ("general").

In 1957 concern was noted about discharge from a cannery in Central Lake. Water quality testing showed 1.6 PPM of D.O. and 50.5° F. water at a depth of 23 feet in mid-July—a low level but not necessarily resulting from cannery waste.

Species of fish identified during the various surveys include Great Lakes muskellunge; northern pike; rock bass; yellow perch; black crappie; bluegill; largemouth bass; longear sunfish; black, yellow, and brown bullhead; blackchin and common shiner; bluntnose minnow; johnny darter; longnose gar; white sucker; and walleye. Adult smallmouth bass were planted in 1940 & 41.

Intermediate River Between Hanley and Intermediate Lakes

This is the shortest stretch of the Intermediate River, flowing only about 0.2 miles until reaching Intermediate Lake. The river flows through the Village of Central Lake,

Aquatic Plant Identification
There are hundreds of species of aquatic plants in Michigan. Aquatic plants are harder to observe than terrestrial plants, their shapes are variable and unusual, and they often do not have conspicuous flowers (one of the best features for plant identification). As a result, identification of aquatic plants can be difficult. One of the best aquatic plant identification references for the amateur naturalist is *Through the Looking Glass: A Field Guide to Aquatic Plants* by Susan Borman, Robert Korth, and Jo Temte. This 248-page guide, published in 1997, is available from the University of Wisconsin Extension's "Wisconsin Lake Partnership" for $20 (call 715-346-4038 for ordering information).

and its banks are quite urbanized. There are 25 property parcels on the river, 23 of which are developed (92%). There are four public accesses, three of which are the ends of Village streets. Old State Road crosses the river where it flows into Intermediate Lake. Only three of the properties have wetlands (12%). Two small unnamed tributaries enter the river. The river mostly has a gravelly/sandy bottom and beds of muskgrass (or Chara) are common.

Intermediate Lake

Intermediate Lake, which was at one time known as Central Lake, is situated between Hanley Lake and Lake Bellaire. It is a moderately productive (mesotrophic) lake and has physical, chemical, and biological characteristics similar to Lake Bellaire.

One of only two islands in the Chain is located in the southern portion of Intermediate Lake. It is the largest of the two, but even so is less than an acre in size and unnamed.

Public access sites include three MDNR boat launch sites, village and township parks, pedestrian access easements, road rights-of-way, and undeveloped county forest land.

Most of the nearshore sediments are sand or gravelly sand. Rocky areas are present along only about 8% of the shore. There are some mucky/marshy areas near the lake's north end. The largest, most important wetlands on Intermediate Lake are wide conifer swamps along the southern and southeastern portions of the shore.

By far, the most common type of aquatic plant in Intermediate Lake is muskgrass (or Chara). Ascending growths of water milfoil or pondweeds are only present along about 22% of the shore.

Nineteen tributaries are present along the lakeshore. Named tributary streams include the Intermediate River (Intermediate Lake's major inlet from Hanley Lake), and Fisk and Openo Creeks.

The MDNR has conducted surveys on Intermediate Lake 13 times: 1891, 1931 ("general"), 1943 (gill net), 1957 (gill net), 1959 (aerial survey of ice fishing activity), 1960 (spear collection), 1962 (fish growth analysis), 1968 (net and electroshocking), 1975 (gill net), 1986 (trap and fyke net), 1997 and 1998 (electroshocking for young walleye), and 1999 (trap, fyke, and gill net).

Species reported during the various surveys include walleye, bluegill, logperch, yellow perch, largemouth and smallmouth bass, pumpkinseed sunfish, longnose gar, white sucker, rock bass, whitefish, cisco, Great Lakes muskellunge, and northern pike.

From 1932 to 1941, largemouth bass, walleye, yellow perch, or rainbow trout were planted. Both rainbow and lake trout were planted between 1944 and 1949, and rainbow and brown trout between 1969 and 1975. Recently (1979 to 1997), walleye have been planted six times (at three or four-year intervals).

The 1931 survey referred to an 1891 report listing rock bass, perch, "grass pike" (most likely northern pike), smallmouth bass, and sunfish as being present in Intermediate Lake.

The 1931 survey concluded that the lake is not considered well suited to coldwater fish due to oxygen depletion in the deepest waters during summer. The 1957 lake survey found 1.2 PPM of D.O and a water temperature of 46 F. at a depth of 80 feet in late July. Testing by the Watershed Council in 1999 revealed that D.O. decreased rapidly below 25 feet, reaching zero by about 33 feet (Figure 36).

The fish growth analysis in1962 found that pike, walleye, and bass had growth rates above the state average. In 1986, whitefish and cisco—to 26 and 19 inches respectively—were captured. A file memo indicated that walleye utilize the rocks by the bridge in Central Lake for spawning.

Electroshocking along one mile of shoreline in 1997 found a large number of young-of-the-year (YOY) walleye, thought to be from natural reproduction. Good smallmouth bass and perch and "ample" rock bass and logperch natural reproduction were also noted. A repeat survey conducted in 1998 (a non-stocking year) also found large numbers of YOY walleye, providing stronger evidence of consistent natural reproduction. If further monitoring continues to find good natural reproduction, walleye stocking could be reduced or even eliminated.

The 1999 survey found that the lake's fish population appeared to be in excellent shape, especially smallmouth bass and walleye (which bears out reports of good fishing for these species in recent years). Fourteen species were captured (including good numbers of lake herring and a few whitefish). All the species which were aged showed above average growth rates.

Intermediate River

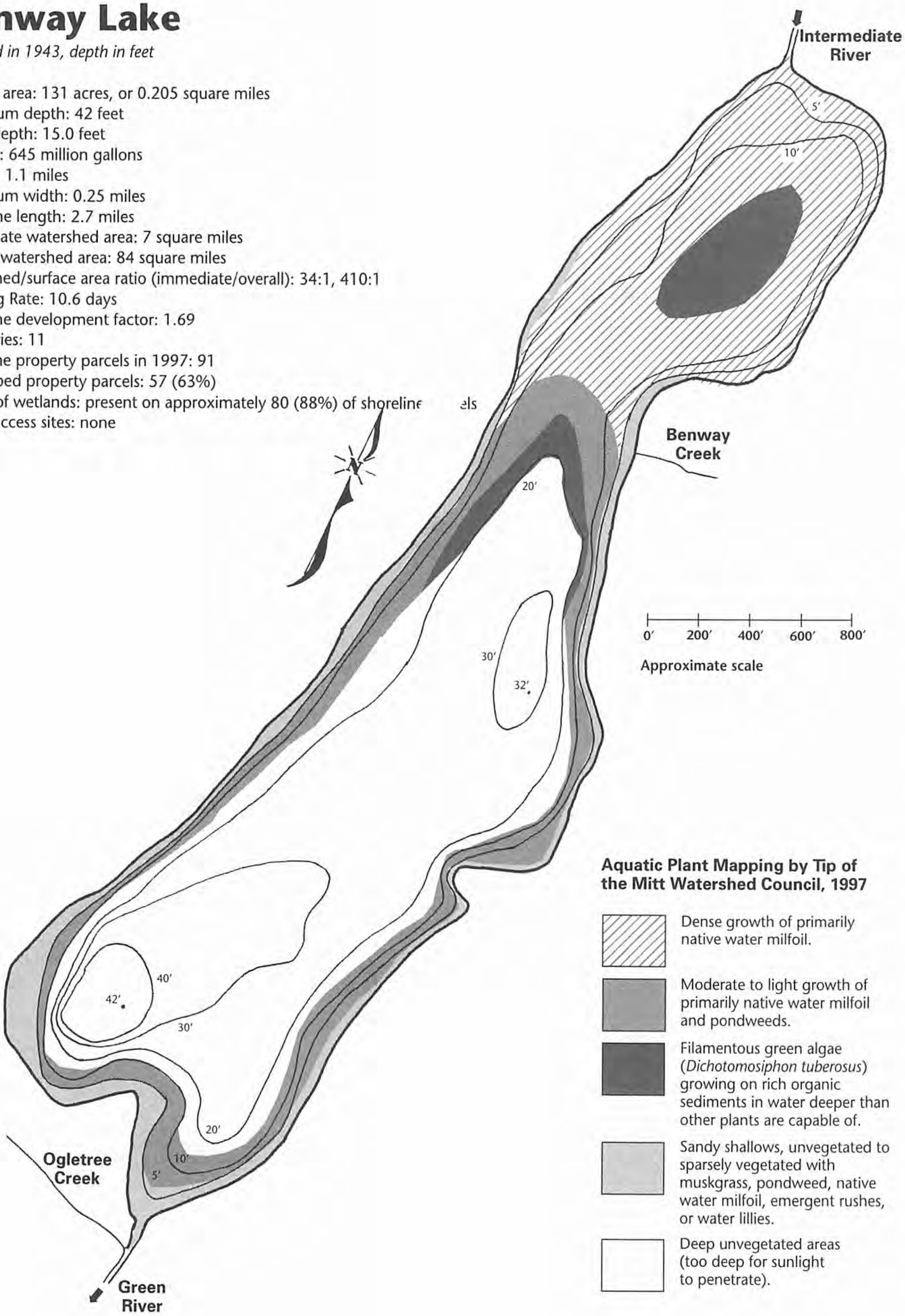
Although the Intermediate River is the name used for several of the interconnecting river segments in the Chain, the stretch between Intermediate Lake and Lake Bellaire is the largest and longest (4.25 miles) of any. The shoreline length is approximately 8.8 miles, because of a backwater area behind the dam. Its overall watershed is about 140 square miles, but its immediate watershed is only about 31 square miles.

A dam is located on this stretch of river, just upstream of the Village of Bellaire. This dam actually backs up water throughout the Upper Chain to Six Mile Lake (the elevation difference between Six Mile Lake and waters behind the dam is less than one foot). It precludes navigation and

Benway Lake

Mapped in 1943, depth in feet

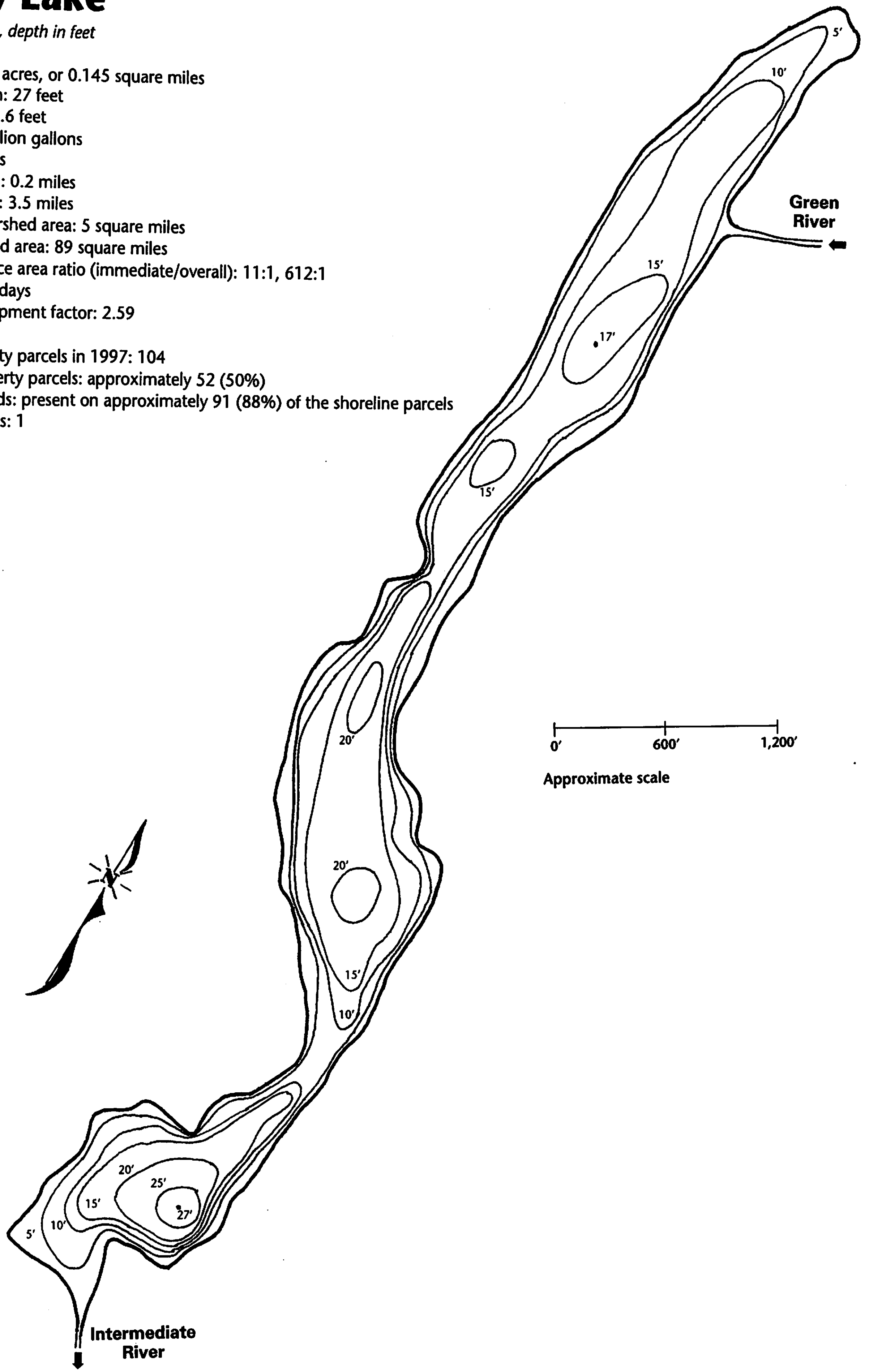
Surface area: 131 acres, or 0.205 square miles
Maximum depth: 42 feet
Mean depth: 15.0 feet
Volume: 645 million gallons
Length: 1.1 miles
Maximum width: 0.25 miles
Shoreline length: 2.7 miles
Immediate watershed area: 7 square miles
Overall watershed area: 84 square miles
Watershed/surface area ratio (immediate/overall): 34:1, 410:1
Flushing Rate: 10.6 days
Shoreline development factor: 1.69
Tributaries: 11
Shoreline property parcels in 1997: 91
Developed property parcels: 57 (63%)
Extent of wetlands: present on approximately 80 (88%) of shoreline ... els
Public access sites: none



Hanley Lake

Mapped in 1943, depth in feet

Surface area: 93 acres, or 0.145 square miles
Maximum depth: 27 feet
Mean Depth: 10.6 feet
Volume: 322 million gallons
Length: 1.5 miles
Maximum width: 0.2 miles
Shoreline length: 3.5 miles
Immediate watershed area: 5 square miles
Overall watershed area: 89 square miles
Watershed/surface area ratio (immediate/overall): 11:1, 612:1
Flushing Rate: 5 days
Shoreline development factor: 2.59
Tributaries: 12
Shoreline property parcels in 1997: 104
Developed property parcels: approximately 52 (50%)
Extent of wetlands: present on approximately 91 (88%) of the shoreline parcels
Public access sites: 1



upstream migration of fish, and is considered the division between the Upper and Lower Chain of Lakes.

The dam was built in the 1890s to raise the water level for floating logs, and subsequently altered to produce power. Although water levels behind the dam have fluctuated over the years, it has raised the level of Intermediate Lake about four feet over the original level. Changes in water level resulting from dam repairs became a divisive issue among lake residents in the late 1980s with some wanting it higher to facilitate navigation, and some wanting it lower to protect septic systems and reduce shoreline erosion. In something of a compromise, a court ruling eventually set the level at the long-term summer average for the period of record keeping.

The river's average annual flow just downstream from Intermediate Lake is 144.6 CFS, 239.2 CFS at M-88 (in downstream Bellaire), and 240 CFS at the river mouth. The big increase in discharge between Intermediate Lake and M-88 is due to the discharge of the Cedar River.

As of 1997, the Intermediate River had 129 shoreline property parcels. Approximately 82 of these are developed (64%). Eighteen parcels on the Intermediate River have public access. They include two boat launch sites in the Village of Bellaire (one below and one above the dam), Richardi Park in Bellaire (which actually consists of several parcels), numerous parcels of city and county land, and two road-stream crossings.

Wetlands appear to be present on approximately 78 (60%) of the shoreline parcels on the Intermediate River. Many of the wetlands consist of a relatively narrow fringe along the shore. Especially noteworthy are wide conifer swamps in both the upper and lower portions of the river.

Most of the river has sand, or sand and gravel bottom sediments. However, about 0.5 mile of river below the dam has a steeper gradient with rocky substrate. Overall, 36% has sand, gravel, and rock; and 64% has sand or gravelly sand. In the Intermediate River, pondweeds and wild celery (or tapegrass) are common in the lower portion, muskgrass (or Chara) in the upper portion, and the middle portion is primarily unvegetated.

The Cedar River, one of the major streams in the ERCOL Watershed, is the only tributary to the Intermediate River.

Although the Intermediate River is not a coldwater stream due to its surface discharge from Intermediate Lake, it is on the MDNR's list of designated trout streams. This is probably due to the seasonal presence of migratory members of the trout family attracted to the fast, rocky riffles below the dam.

Walleye are also known to congregate below the dam on their spring spawning runs. This was documented in a Fisheries Division report in 1945. It is likely that other species also use the habitat below the dam for spawning.

Lake Bellaire

Lake Bellaire is situated between Intermediate Lake and Clam Lake. It was formerly known as Grass Lake. It is a moderately productive (mesotrophic) lake with physical, chemical, and biological characteristics similar to Intermediate Lake.

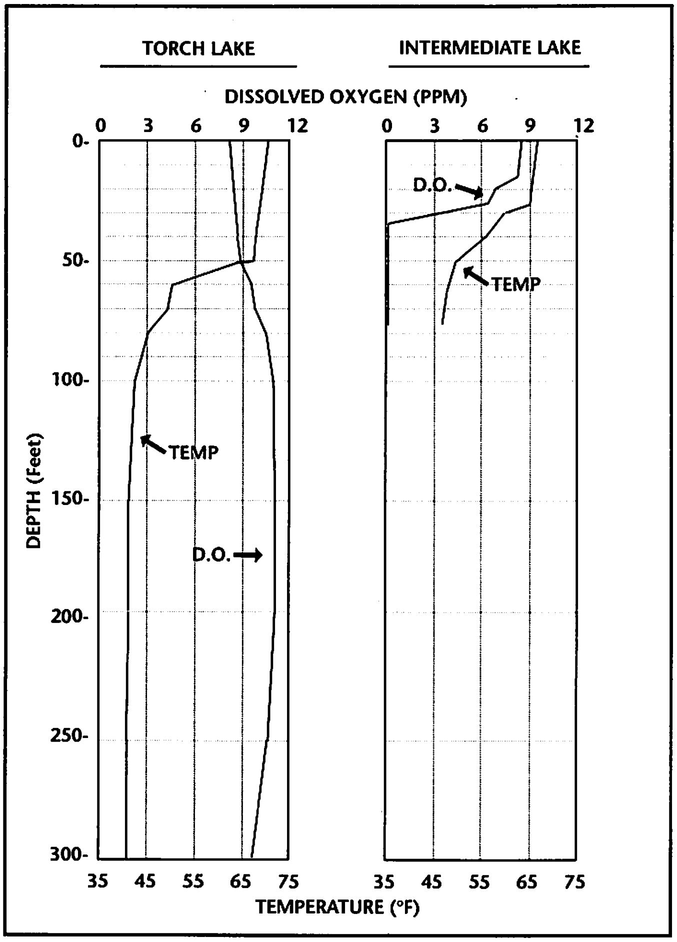


Figure 36 - Intermediate and Torch Lakes have very different late summer dissolved oxygen (D.O.) profiles. Intermediate Lake's D.O. level drops off sharply at about 25 feet, with the lower water becoming devoid of D.O. Oxygen depletion of this nature is probably a normal occurrence in the deeper lakes of the Upper Chain (due primarily to decomposition of large amounts of plants and algae), as previous surveys dating back to the 1930s have documented. In contrast, Torch Lake actually has more D.O. in the cold waters deeper than 50 feet, because of its large volume and low productivity. See Chapter Two for more information about lake stratification and D.O.

The level of Lake Bellaire is a little higher than it was originally because the dam at Elk Rapids impounds water this far upstream. It is possible to take a fairly large motorboat from Lake Bellaire all the way to Elk Rapids, a distance of about 25 miles.

Public access sites include two MDNR boat launches, an MDNR access park, a township access site, and seven road endings.

Most of the undeveloped properties along the lakeshore are wetlands. The lake's largest wetlands are extensive conifer or mixed hardwood/conifer swamps on the north end, marshy areas west of the mouth of the Intermediate River, and marshy and swampy areas on the south end (most of which are in the Grass River Natural Area).

Most of the lakeshore (about 62%) has sand or gravelly-sand nearshore bottom sediments. The rest of the lake (mostly in the North Arm area) has a muck or marly sand bottom. There are virtually no rocky shorelines on Lake Bellaire, which is unusual for a lake of this size in the Elk River Watershed. This has been identified as a potential problem for successful spawning of some fish species.

In Lake Bellaire, muskgrass (or Chara) is the most common aquatic plant. Ascending growths of water milfoil or pondweeds are only found in the vicinity of 13% of properties, mostly around the mouth of the Intermediate. River. Aquatic plants are absent from about 25% of the shoreline.

There are two named tributaries, the Intermediate River (Lake Bellaire's major inlet from Intermediate Lake), and Grass Creek, which flows into the north end of the North Arm.

The MDNR has conducted surveys for fish community composition and age and growth, water analysis, aquatic habitat inventory, or other features 13 times: 1891, 1931 (seine net), 1942 (gill net), 1949 ("general" with creel census), 1955 (fish report), 1957(gill net), 1959 (aerial ice fishing survey), 1962 (trap net), 1971 (gill net), 1996 (otter trawl and gill net), 1987 (gill net), 1993(trap net), and 1998 (electroshocking).

The 1931 survey summary makes reference to an 1891 report listing trout, whitefish, perch, herring, "grass pike" (probably northern pike), rock bass, and smallmouth bass as being present in Lake Bellaire. Since 1931, the following species have been reported: northern pike, largemouth and smallmouth bass, bluegill, rock bass, lake trout, longnose gar, white sucker, brook silverside, blunt nose minnow, unidentified minnows, walleye, brook trout, black crappie, yellow perch, white sucker, brown trout, splake, pumpkinseed sunfish, brown bullhead, cisco, and smelt.

Between 1932 and 1990, largemouth bass, bluegill, perch, lake trout, splake, rainbow trout, brown trout, and walleye were all periodically stocked. Since the 1990's only brown trout, walleye, and splake have been planted. A management prescription in 1993 called for continued stocking only of walleye (at three year intervals) the reason being limited natural recruitment (due to the absence of spawning substrate), but good potential for survival and growth.

The 1971 survey found a high incidence of tapeworm and bladderworm infestations in splake. Fish captured in 1976 had above-average growth rates, but in 1993 growth rates were about average. Water chemistry conducted in late July, 1957, found 41.5° F. water with 5.3 parts per million (PPM) of D.O. at a depth of 90 feet. In early August, 1976, 48° F. water with 4 PPM D.O. at a depth of 80 feet was found. Other, more recent, studies have found slightly lower late summer oxygen levels in the bottom water. It appears that Lake Bellaire still has enough cold, well-oxygenated water during summer to be considered suitable for a coldwater fishery, and most management efforts over the years have been for various species of trout.

A 1977 file memo reported a smelt die-off, but no cause could be found. In 1987, the survey found a good population of walleye with natural recruitment, many smallmouth bass of large size, as well as large lake and brown trout. In 1993, trap nets were set at the mouth of the Intermediate River to assess the Atlantic salmon population following reports of these fish in the River near Bellaire. A total of 99 fish, but no Atlantic salmon, were caught in eight nights. Notes associated with the survey mentioned that there is a fall splake and spring smelt fishery in the Intermediate River. A 1998 electroshocking survey showed evidence of natural reporduction of walleye in 1996 and 1998. By monitoring the strength of natural reproduction, stocking with pond-reared walleye could be done more effectively, with stocking unnecessary in years following large natural recruitment. Yellow perch, smallmouth bass, and cisco have been considered to be common to abundant over the years. The MDNR considers Lake Bellaire to have some of the best trophy smallmouth bass fishing in the area.

Grass River

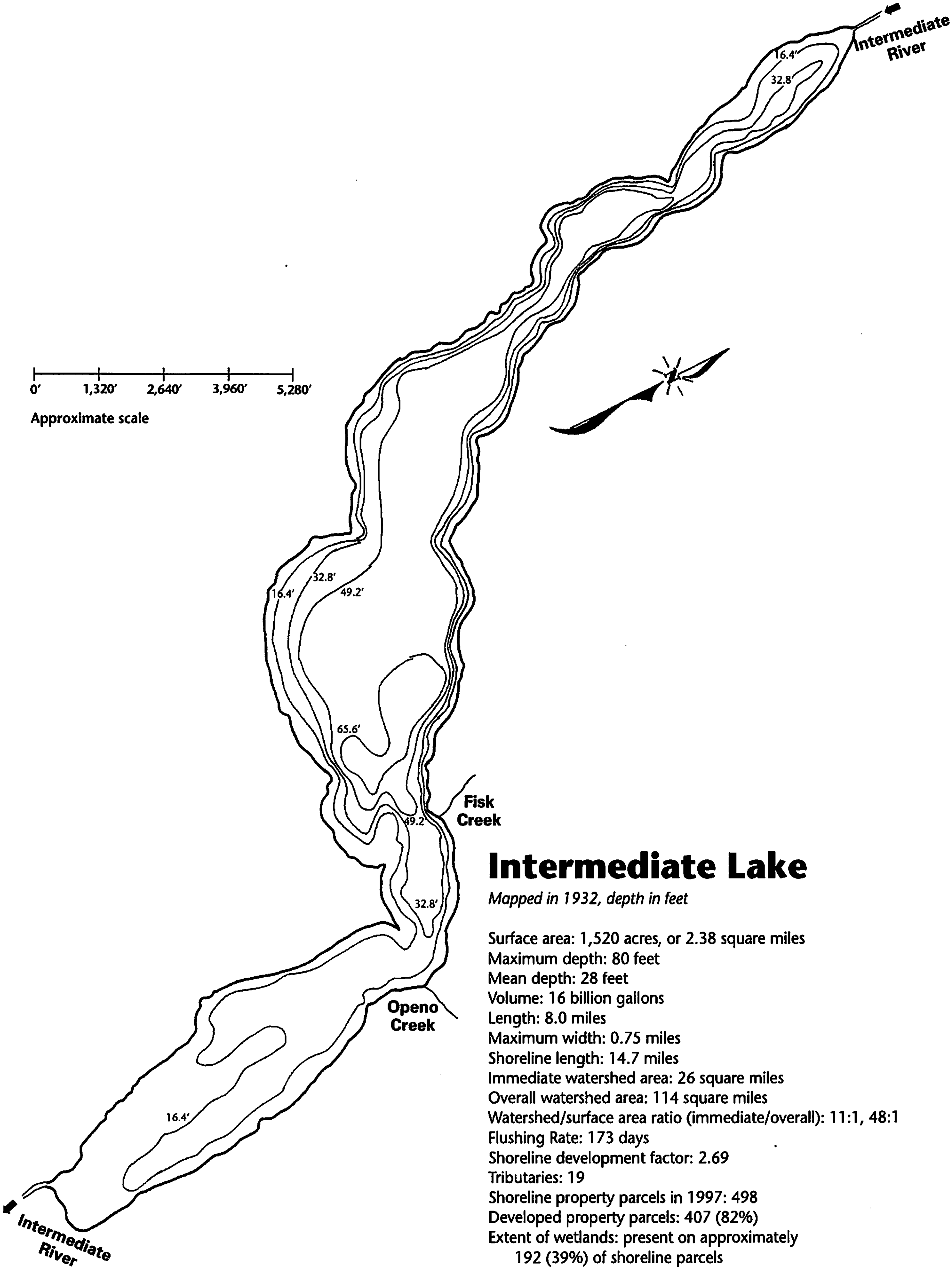
Grass River is 2.5 miles long and flows generally southwest, connecting Lake Bellaire to Clam Lake. Its overall watershed is about 175 square miles, but its immediate watershed is about 14 square miles. The river's average annual flow just downstream from Lake Bellaire is 268.3 cubic feet per second, making it navigable by moderate-sized powerboats. Because of heavy traffic and concerns about safety and environmental damage, the entire river is a slow-no-wake zone, and it takes about two hours to make a round trip.

The Grass River is one of the most scenic spots along the Chain of Lakes. It flows through an expansive marsh and dense conifer swamps. Most of the river is undeveloped, and is protected by the Grass River Natural Area, a 1,100-acre Antrim County preserve. The Grass River and surrounding wetlands are accessible to non-boaters via the Natural Area's boardwalk system allowing access to the dense swamp and marsh while minimizing impacts on the fragile ecosystem. The Natural Area's trail guide lists 49 species of mammals, 33 reptiles and amphibians, 65 species of birds, 35 fish, and more than 400 plants in six basic habitat types. There are a number of foot bridges where trails cross Finch Creek, providing places for relaxing and watching fish and other wildlife.

As of 1997, there were 37 shoreline property parcels along the Grass River. Approximately 12 of these parcels are developed (32%). Seven parcels on the Grass River have public access. They include Grass River Road ending, and all of the parcels owned by Antrim County comprising the Grass River Natural Area.

Wetlands appear to be present on all 37 of the shoreline parcels on the Grass River. In a few places the wetlands consist of a relatively narrow fringe along the shore. Especially noteworthy are wide conifer swamps within the Grass River Natural Area, and the large marsh near the head of the river on its west side.

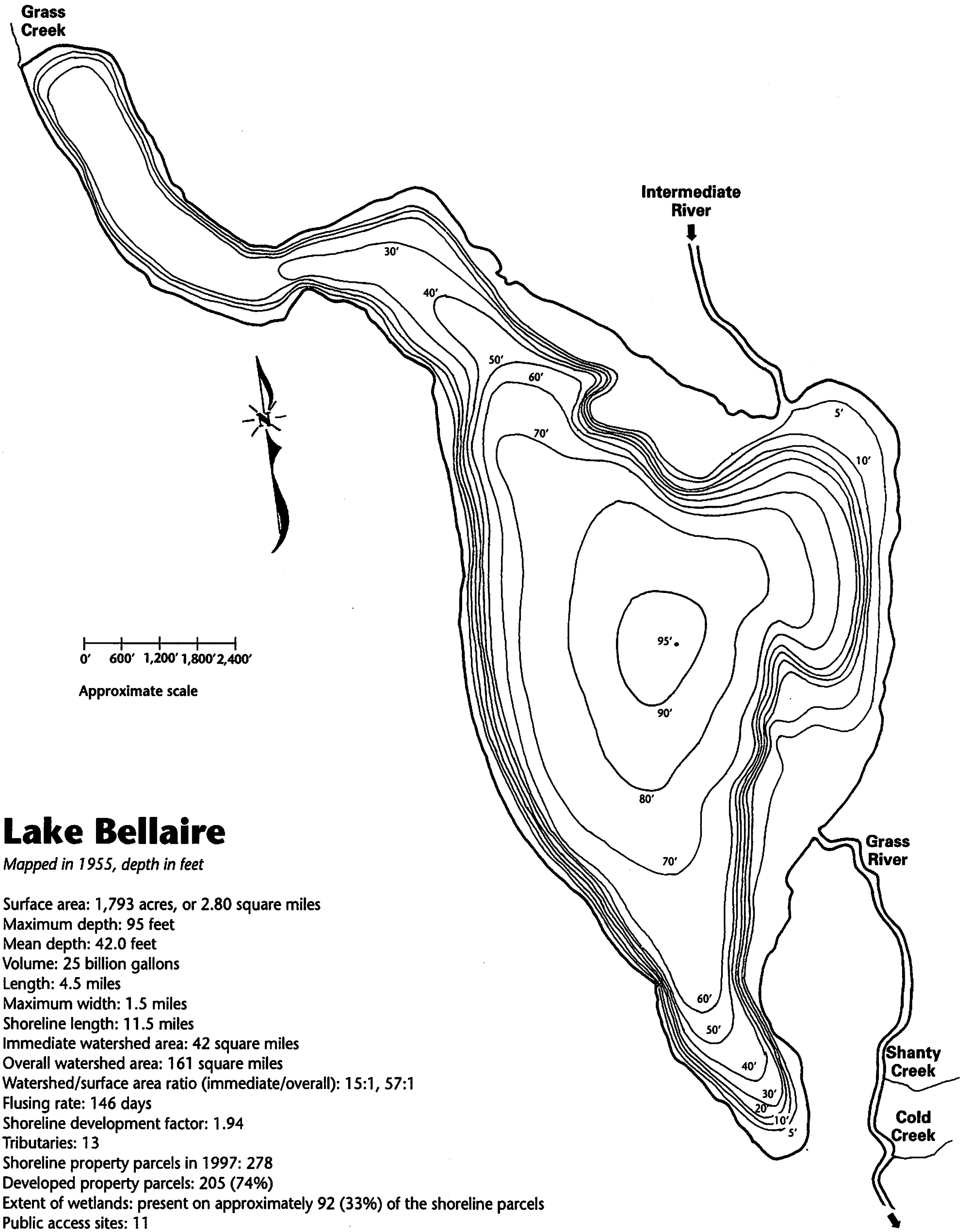
An environmental survey conducted by the Grass River Natural Area in 1984 found warm water conditions (mean monthly summer temperature typically exceeding 68° F.). The current is slow and non-turbulent (the river's elevation drops less than six inches over its 2.5 mile course). The bottom is sandy near the head of the river. The three primary tributaries to the Grass River (Shanty, Cold, and Finch Creeks), each contribute organic material to the Grass River, resulting in more silty/muddy conditions near the mouth and on the fringes of the river where the current velocity is less. This organic material is an important source of energy to the river. A large amount of woody debris is



Intermediate Lake

Mapped in 1932, depth in feet

Surface area: 1,520 acres, or 2.38 square miles
Maximum depth: 80 feet
Mean depth: 28 feet
Volume: 16 billion gallons
Length: 8.0 miles
Maximum width: 0.75 miles
Shoreline length: 14.7 miles
Immediate watershed area: 26 square miles
Overall watershed area: 114 square miles
Watershed/surface area ratio (immediate/overall): 11:1, 48:1
Flushing Rate: 173 days
Shoreline development factor: 2.69
Tributaries: 19
Shoreline property parcels in 1997: 498
Developed property parcels: 407 (82%)
Extent of wetlands: present on approximately 192 (39%) of shoreline parcels
Public access sites: 13



Lake Bellaire

Mapped in 1955, depth in feet

Surface area: 1,793 acres, or 2.80 square miles
Maximum depth: 95 feet
Mean depth: 42.0 feet
Volume: 25 billion gallons
Length: 4.5 miles
Maximum width: 1.5 miles
Shoreline length: 11.5 miles
Immediate watershed area: 42 square miles
Overall watershed area: 161 square miles
Watershed/surface area ratio (immediate/overall): 15:1, 57:1
Flusing rate: 146 days
Shoreline development factor: 1.94
Tributaries: 13
Shoreline property parcels in 1997: 278
Developed property parcels: 205 (74%)
Extent of wetlands: present on approximately 92 (33%) of the shoreline parcels
Public access sites: 11

Was fishing really better in the "Good Old Days"

What was the fish community, and fishing, like in days gone by? We know that some fish, like grayling and sturgeon, have disappeared from waters of the Chain. Pictures and stories abound about the "good old days," which show fish of the kind, numbers, and size not found much today. But, unfortunately, there is very little scientifically valid information to quantify these questions.

In Glenn Ruggles' *Voices on the Water—An Oral and Pictorial History of Antrim County's Chain of Lakes*, a number of long-time residents reminisce about how things were in days gone by.

"You could go out there with a boat and look down thirty feet and see logs layin' at the bottom. You can't see down half that far now" is how Bill DeFauw describes Elk Lake in the 1940s. Many of the people interviewed by Ruggles make the same complaint.

Of ice fishing on Elk Lake, Gertie Barber (who started fishing at the age of four in 1906) says "You didn't have to fish very long and you had your limit. You could look down and see fish all over, and now you can't see nothing. There's gotta be something wrong."

Thale Yettaw of Ellsworth, when asked if fishing has changed on any of the lakes, replied "Oh, I wouldn't say these are fishing lakes anymore. But it's as good as anything there is in the country. Man is his own worst enemy—greed has a lot to do with it. If the fish were bitin' out there, he'd sit right there until he caught every one and take 'em home and throw 'em away."

All of the dozens of people Ruggles interviewed agree that fishing was better in the past, even without the benefits of modern tackle and other equipment (although some indicate that water quality was poorer back then).

In October, 1996, 4,150 questionnaires containing 45 questions pertaining to water resource management and features were sent to all riparian property owners along the Chain of Lakes. The questionnaires were part of regionally-coordinated watershed management project. About 15% (616) were returned. Some of the questions dealt with fish and fishing. About 31% of respondents indicated that someone in their household fishes routinely. Bass were fish most commonly sought-after or caught, followed by trout, perch, walleye, pike, rock bass, bluegill, and other "panfish." About 61% felt that fishing had declined in recent years, while 32% thought that it had improved, and 7% thought it had remained steady.

The earliest fish surveys from the Chain of Lakes by the old Michigan Department of Conservation suggest that, in general, fish community composition and population structures were similar to those of today. If that is true, why don't people think fishing is as good today? Are there really a lot fewer sport fish today than there used to be? Are the fish getting "smarter" and harder to catch? Are the memories and stories really accurate, or are they selective and have been embellished over time?

One thing is certain—lakes can only produce and support a certain number of fish (termed standing crop, and often expressed in pounds per acre), and there are a lot more people on the lakes trying to catch what basically amounts to the same number of fish. This means less fish per person to go around. Although fishing may never be as good as in the old days, by wisely conserving resources, practicing catch and release, and protecting habitat and water quality, it is likely that the lakes will continue to be, as Thale Yettaw put it, "as good as anything there is in the country."

present, especially on the channel margins. The river's mainstream has extensive beds of muskgrass (or Chara), with lesser amounts of wild celery (or tapegrass), pondweeds, and Elodea. There are many backwater areas vegetated with water lily, pond lily, and floating-leaved pondweed. These backwaters provide important cover, spawning areas, and food for fish.

The fish of the Grass River are a typical assemblage of warm water fish common throughout the Chain of Lakes: pike, perch, bass, bluegill, pumpkinseed sunfish, longear sunfish, black bullhead, johnny darter, slimy sculpin, blackchin shiner, blacknose shiner, and "large schools of unidentified minnows." Although the Grass River is not a coldwater stream, due to its surface discharge from Lake Bellaire, it is on the MDNR's list of designated trout streams, likely due to the seasonal presence of migratory trout heading to and from the three tributaries.

Clam Lake

Clam Lake is situated between Lake Bellaire and Torch Lake. The outlet of Clam Lake is the short Clam River, which flows from East Torch Lake Drive to Torch Lake, less than 0.25 mile. The banks of the Clam River are quite built-up with marinas, restaurants, and residential homes. The river's average annual flow at East Torch Lake Drive is 335.8 CFS.

Public access sites include an MDNR boat launch, several road end easements, the East Torch Lake Road crossing of the Clam River, and lands in Antrim County's Grass River Natural Area. The most extensive wetlands are the marshes and swamps at the mouth of the Grass River, Clam Lake's inlet.

There are three basic nearshore bottom types on Clam Lake and the Clam River: sand (55% coverage), a mixture of rock, gravel and sand (25%), and muck (21%). The Clam River has a rocky/gravelly substrate in many places.

In Clam Lake, about 70% of the shoreline has ascending growths of water milfoil or pondweeds, 10% has floating-leaved plants, and 20% has sparse or absent plant growth. The only named tributary to Clam Lake is the Grass River, Clam Lake's major inlet from Lake Bellaire.

A 1993 study found higher than expected nutrient levels in Clam Lake. The source was unknown, but septic systems, shoreline erosion, bottom sediment resuspension from heavy motorboat traffic, or natural seasonal nutrient discharges from the large wetlands just upstream were suspected.

The MDNR has surveyed Clam Lake seven times: 1888, 1931 ("general"), 1942 (gill net), 1958 (gill net and seine haul), 1959 (aerial survey of ice fishing activity), 1961 (fish growth analysis), and 1975 ("general").

Species reported during the various surveys include central mudminnow; longnose gar; northern pike; yellow perch; brown, black, and yellow bullhead; large-and smallmouth bass; bluegill; rock bass; white sucker; pumpkinseed sunfish; longear sunfish; Great Lakes muskellunge; blacknose, spottail, blackchin, emerald, and sand shiner; bluntnose minnow; banded killifish; logperch; and johnny and Iowa darter.

The 1931 survey reports that fishing, especially for bass, pike, and musky, was better in the past (Figure 37).

Largemouth bass, bluegill, or walleye (referred to in the report as "yellow pike-perch") were planted between 1932 and 1939.

A gill net survey for cisco in the Clam River on November 3, 1942, failed to take any. The report concluded that the spawning run was over, having occurred unseasonably early during the last two weeks of October. However, emerald shiners were noted as being extremely abundant. They were still reported to be abundant in 1965, at which time the Fisheries Division was being pressured to lift the ban on commercial bait harvesting there. A file note reports that a 54-inch, 56-pound Great Lakes muskellunge caught by an angler in 1952 was found to be 13 years old. The conclusion of the 1958 survey was that there is a good variety and abundance of species and since no fishing problem was evident, no management actions were needed. A 1991 file note reported good black crappie and pike fishing and fair perch fishing.

Figure 37 - Both Clam and Skegemog Lakes have long been renowned for musky fishing. Cash Woodruff of Mancelona (the author's great grandfather) speared this 47-pound fish through the ice of Clam Lake in the 1920s. A 47-pound 12-ounce fish caught by Wendell Nichols of Bellaire in Clam Lake in 1985 was recognized as Michigan's state record until May, 2000, when a 48-pounder caught in Skegemog Lake by Charles Edgecomb Sr. of Rapid City in 1984 was verified. Reports of larger fish taken over the years have not been verified.

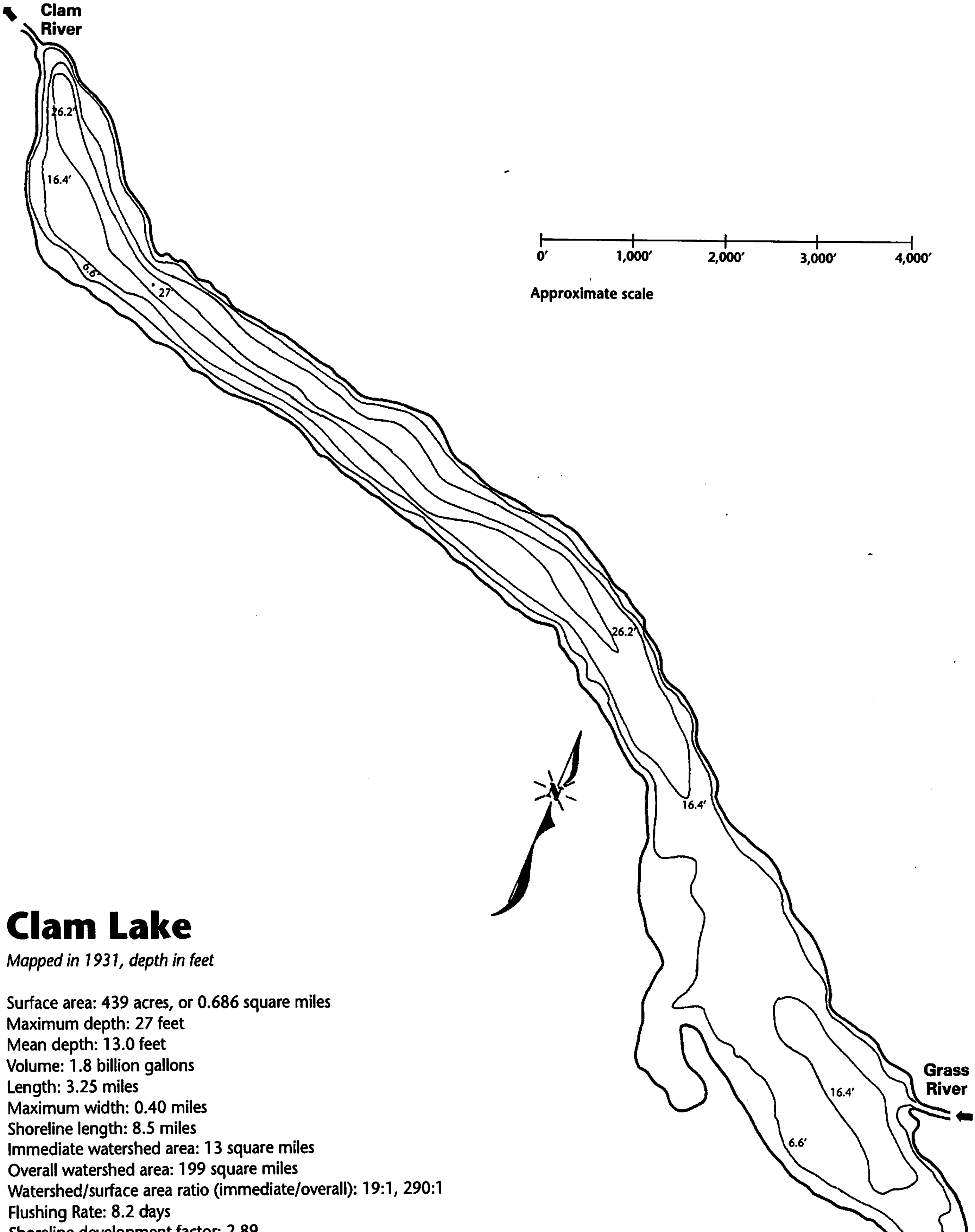
Torch Lake

Torch Lake is one of the most extraordinary lakes in Michigan. Its surface area is second largest in Michigan, but its great depth (about 300 feet, depending on the map) gives it by far the greatest water volume of any inland lake in the state. As a result, Torch Lake has the longest flushing rate of any lake in the Chain. Often, it does not freeze because of the large amount of heat stored in its vast volume. It is also Michigan's longest inland lake. With a steady 35 mile per hour north or south wind, waves up to 4.5 feet high can develop.

As a result of this great volume and relatively small immediate watershed, Torch Lake has exceptionally high water quality. Data on dissolved oxygen, temperature, water clarity, chlorophyll-a (a measure of the amount of algae in the water), and phosphorous shows that the water quality is well within the oligotrophic (highest quality) category. The low nutrient levels mean that the lake waters do not support a lot of algae, and are thus quite clear. The clarity of the lake in summer as measured with a Secchi Disk (Figure Ten) is usually between 20 and 30 feet. Oxygen levels in the deepest waters of the lake actually remain higher than surface waters throughout the summer (Figure 36). Most other deep Northern Michigan lakes experience at least some depletion in bottom waters.

Formerly a deep, fjord-like bay of ancient Lake Michigan, Torch Lake became an inland lake when a sand bar formed across the mouth of the bay (now the lake's northwest end). The shoreline consists mostly of cobble-sized (2.5-10" diameter) rocks. However, large areas of sand are present in some areas, most notably at the north and south ends. Bottom sediments in the deepest waters are grey or white in color due to the deposition of marl with only low levels of organic material. Almost everywhere, the lake has a wide, sandy, shallow region paralleling the shore which ends in a steep drop-off. Aquatic plants are sparse, with muskgrass (or Chara) being the most abundant. Pondweeds, water milfoil, and wild celery (or tapegrass) are found in only a few locations.

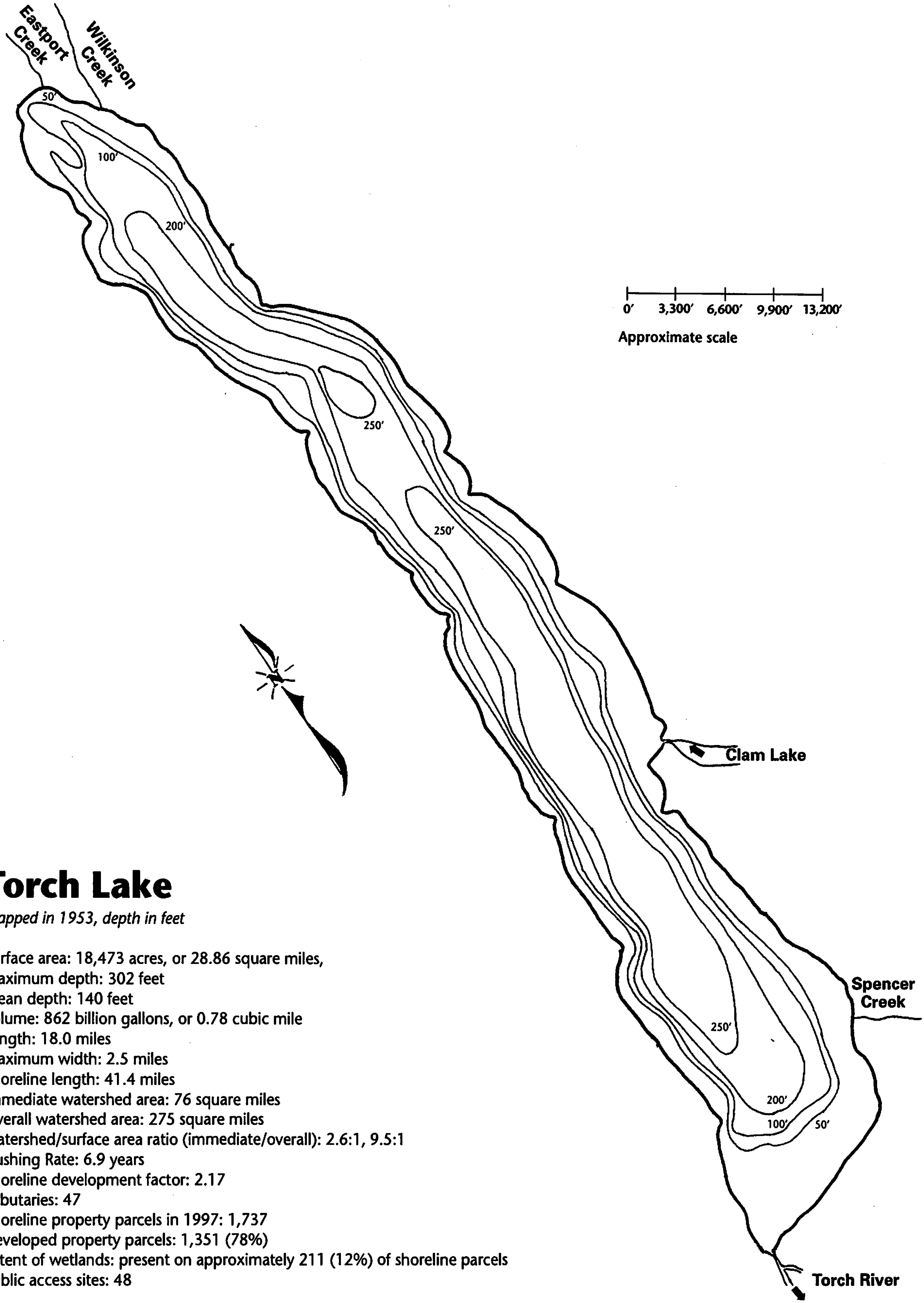
Named tributaries include the Clam River (Torch Lake's major inlet); and Spencer, Wilkinson, and Eastport Creeks. All of the other tributaries are very small and apparently



Clam Lake

Mapped in 1931, depth in feet

Surface area: 439 acres, or 0.686 square miles
Maximum depth: 27 feet
Mean depth: 13.0 feet
Volume: 1.8 billion gallons
Length: 3.25 miles
Maximum width: 0.40 miles
Shoreline length: 8.5 miles
Immediate watershed area: 13 square miles
Overall watershed area: 199 square miles
Watershed/surface area ratio (immediate/overall): 19:1, 290:1
Flushing Rate: 8.2 days
Shoreline development factor: 2.89
Tributaries: 5
Shoreline property parcels in 1997: 258
Developed property parcels: 170 (66%)
Extent of wetlands: present on approximately 114 (44%) of the shoreline parcels
Public access sites: 5



Torch Lake

Mapped in 1953, depth in feet

Surface area: 18,473 acres, or 28.86 square miles,
Maximum depth: 302 feet
Mean depth: 140 feet
Volume: 862 billion gallons, or 0.78 cubic mile
Length: 18.0 miles
Maximum width: 2.5 miles
Shoreline length: 41.4 miles
Immediate watershed area: 76 square miles
Overall watershed area: 275 square miles
Watershed/surface area ratio (immediate/overall): 2.6:1, 9.5:1
Flushing Rate: 6.9 years
Shoreline development factor: 2.17
Tributaries: 47
Shoreline property parcels in 1997: 1,737
Developed property parcels: 1,351 (78%)
Extent of wetlands: present on approximately 211 (12%) of shoreline parcels
Public access sites: 48

Figure 38 - An example of one of the hundreds of small unnamed tributaries to the Chain of Lakes.

unnamed (Figure 38). The Torch River flows out of the south end of the lake.

Public access sites on Torch Lake include MDNR boat launch sites, county and township parks, and many road endings and pedestrian access lanes.

The occurrence of shoreline wetlands is by far the lowest amount of any lake in the Chain.

The MDNR has surveyed Torch Lake 21 times: 1888, 1923 ("general"), 1931 ("general"), 1957 to 1965 (aerial survey of ice fishing activity), 1958, 1966, 1970, 1972, 1975, 1985 (experimental gill net surveys), 1991 (gill net), 1993 (trap nets targeting Atlantic salmon), 1994 (gill net collection of whitefish for contaminant analysis), and 1997 (gill net for Atlantic salmon, and trap net for warmwater fishery).

Fish species commonly collected in 1888 were not much different than those found today: lake trout, burbot, whitefish, herring (a.k.a. cisco), yellow perch, white sucker, horned (?) dace, bluntnose minnow, logperch, johnny darter, sculpin, and lake (emerald?) shiner. Largemouth and smallmouth bass, rock bass, and brook trout were also collected.

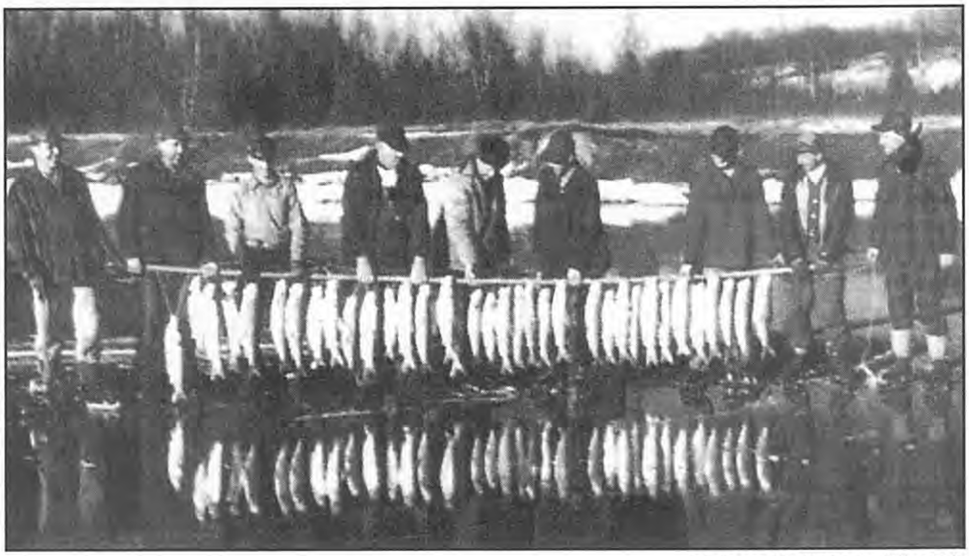
Records show that 10 species have been periodically or annually stocked in Torch Lake since 1882, when Atlantic salmon were first introduced. From 1925 to 1986, stocking was mostly with lake trout and some rainbow trout. Walleye and bluegill were stocked from 1934 to 1939. Kokanee salmon were planted in 1965-66.

Between 1986 and 1996, Atlantic salmon, and brown and rainbow trout were periodically planted. In accordance with the most recent management prescription, only Atlantic salmon have been stocked since 1996. There are no plans to resume stocking other species as long as the Atlantics continue to create an excellent fishery (as indicated by informal creel reports).

Besides Atlantic salmon, Torch Lake has long been noted for its coldwater fishery for lake trout and whitefish (Figure 39), both of which are self sustaining through natural reproduction. Surveys throughout the years have indicated stable, healthy populations of lake whitefish, cisco, and lake trout, with many year classes represented. Cisco are abundant (although slow growing), and appear to be a major prey of the lake trout. Burbot and deep water sculpin are also both common in the deeper areas. The warmwater fishery apperas to be in "acceptable" shape, with rock bass and smallmouth bass dominating. Although they are not abundant, they have a good size distribution. The 1997 survey captured lake trout to 38", whitefish to 24", cisco to 13", smallmouth bass to 21", and rock bass to 11".

The deep water community association is reminiscent of Lake Michigan's before it was disrupted by exotic organisms (lamprey, alewife, etc.), over-fishing, and toxic pollution. Smallmouth bass, yellow perch, and rock bass are the most common cool-water game species. Fishing pressure is generally considered to be light. Because of its low productivity, Torch Lake does not yield large numbers of fish.

As beautiful as Torch Lake appears, its lake trout contain



(photo provided by Walter Kirkpatrick)

Figure 39 - This locally famous photo shows a large quantity of whitefish speared by a group of local men in February, 1952. Rare conditions of smooth, clear ice allowed skaters to see fish through the ice, and herd them to shallow water, where spearers waited over holes cut in the ice.

levels of Chlordane, a cancer-causing pesticide which has been partially banned since 1983 and completely banned since 1988. The Chlordane probably originated from use on lawns or agricultural areas in Torch Lake's immediate watershed. The contamination is high enough that an advisory has been issued against eating any lake trout over 26 inches (see the Michigan Department of Community Health's fish advisory booklet for more detailed information).

Torch River

The Torch River flows about 2.1 miles between Torch and Skegemog Lakes. Its elevation only drops several inches over this distance. Because of some backwater areas (especially an area at the north end known as the bayou), its shoreline length is about five miles. Its overall watershed is about 427 square miles, while its immediate watershed is about 151 square miles.

There are two tributaries along the Torch River. Only one is named (the Rapid River) which is the largest non-connecting tributary to the Chain of Lakes. Torch River's average annual flow at County Road 593 (Crystal Beach Road) is about 523 CFS. The river forms the boundary between Antrim and Kalkaska Counties.

As of 1997, there were 182 shoreline property parcels on the river, approximately 139 of which were developed (76%). Two parcels on the Torch River have public access—a MDNR boat launch and undeveloped state land on the lower river which is part of the Skegemog Natural Area. Wetlands appear to be present on approximately 135 (74%) of the shoreline parcels on the Torch River. Many of the wetlands consist of a relatively narrow fringe along the shore, but there are more extensive wetlands in some places.

The bottom sediments of the Torch River are primarily sand, especially in mid-stream. However, there are areas of mucky sand and soft muck along the river's margins. Between the head of the river and the inlet of the Rapid River, the water is very clear and the bottom consists of "clean, white sand." Due to constant deposition of silt and organic material by the Rapid River, the sand becomes mixed or coated with these materials downstream of the Rapid's mouth. Because the river's current has the ability to suspend, or resuspend, fine sediments, water clarity drops steadily as the river approaches Skegemog Lake. There is quite a bit of woody material as well as stumps and standing dead trees in the water (a sign of the impoundment by the Elk Rapids Dam).

Muskgrass (or Chara) and wild celery (or tapegrass) grow commonly throughout the river. In some areas, especially near the river's mouth and some portions of the Bayou, ascending growths of pondweeds or water milfoil are also present. Floating leaved aquatic plants grow in some quiet margins and backwaters.

The MDNR has conducted fishery surveys of the river eight times (1945, 1951, 1952, 1953, 1955, 1978, 1980, and 1995), mostly visual surveys to observe spawning Great Lakes muskellunge, or trap netting to collect eggs. Over the years, 2.7 to 7.6 fish per hour have been seen. In 1995, there seemed to be lower abundance, but the observations were within the same range, and the data was not conclusive (more observations were recommended). The 1945 survey's description of the river's water quality, bottom type, and vegetation is similar to that of today. The report indicated that musky congregate in the shallow mud flats near the mouth of the Rapid River, and that about 30-40 were harvested there annually. In 1951, the survey included collecting fish by spearing, netting, and hook and line. Rainbow trout, yellow perch, rock bass, cisco, white sucker, smallmouth bass, and pumpkinseed sunfish were taken in addition to Great Lakes muskellunge. A file memo of 1951 reports the catching of a natural pike-musky hybrid (a "tiger musky").

Spearing of musky in the Torch River was finally banned in 1959. Although the Torch River is not a coldwater stream (due to its surface discharge from Torch Lake), it is on the MDNR's list of designated trout streams, likely due to the seasonal presence of migratory trout heading to and from the Rapid River. Atlantic salmon have also been observed trying to spawn in the river during fall. Fishery biologists have raised concern about the impact of recreational boat traffic on the river's fish and fish habitat. On busy summer weekends, hundreds of boats per hour have been counted.

Skegemog Lake

Skegemog Lake is situated between Torch Lake and Elk Lake. It was formerly known as Round Lake. It is connected to Elk Lake via a 1/4 mile-wide, seven-foot deep narrows (called the Skegemog Narrows). Elk and Skegemog Lakes are at the same elevation.

Eighty percent of shoreline property parcels are developed. However, this is a misleading statistic because several large parcels of land on the lake's eastern end having a shoreline length of over seven miles (the majority of the lakeshore) are undeveloped. These parcels comprise the Skegemog Swamp, one of the largest wetlands in the region. They are State-owned, managed by the MDNR as the Skegemog Natural Area, and open for public use. Other public access sites include two MDNR boat launches, several road endings, and several Grand Traverse Regional Land Conservancy preserves.

The nearshore bottom sediments of Skegemog Lake are primarily sand (70%) followed by a mixture of rocks, gravel and sand (29%), with the rest (mostly in the eastern end) being soft muck or marl. The eastern end of the lake is shallow, and submerged logs and stumps are present quite a way offshore in places. The logs and stumps are from trees that once grew in a lakeside conifer swamp, but which were inundated by impoundment from the Elk Rapids dam.

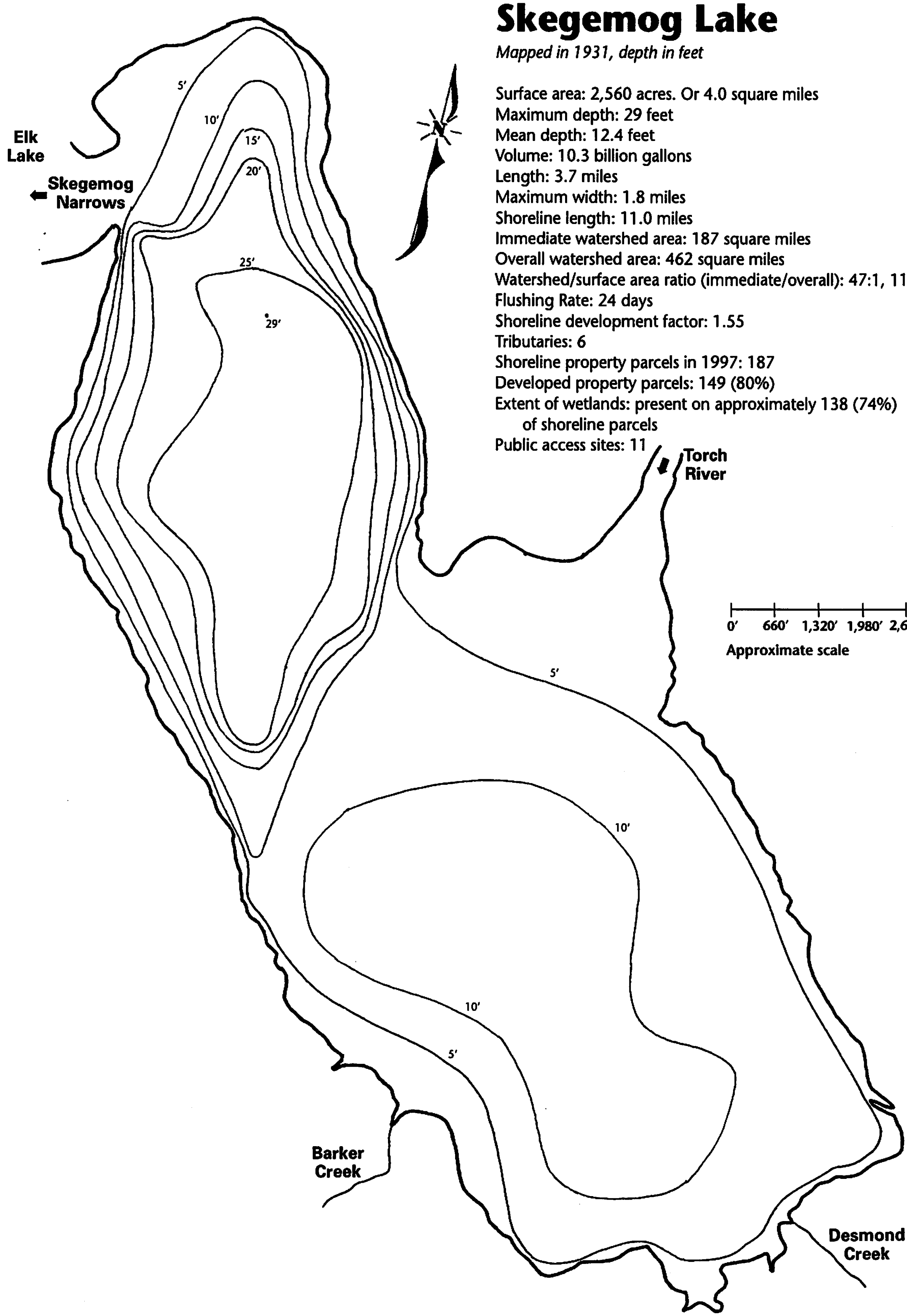
About half of the nearshore shallows are vegetated with muskgrass (or Chara), sago pondweed, and other species, with the remainder being mostly unvegetated. Because of Skegemog Lake's fairly clear waters and shallow depth, aquatic plants grow throughout much of the lake. The only named tributaries are the Torch River, Desmond Creek, and Barker Creek.

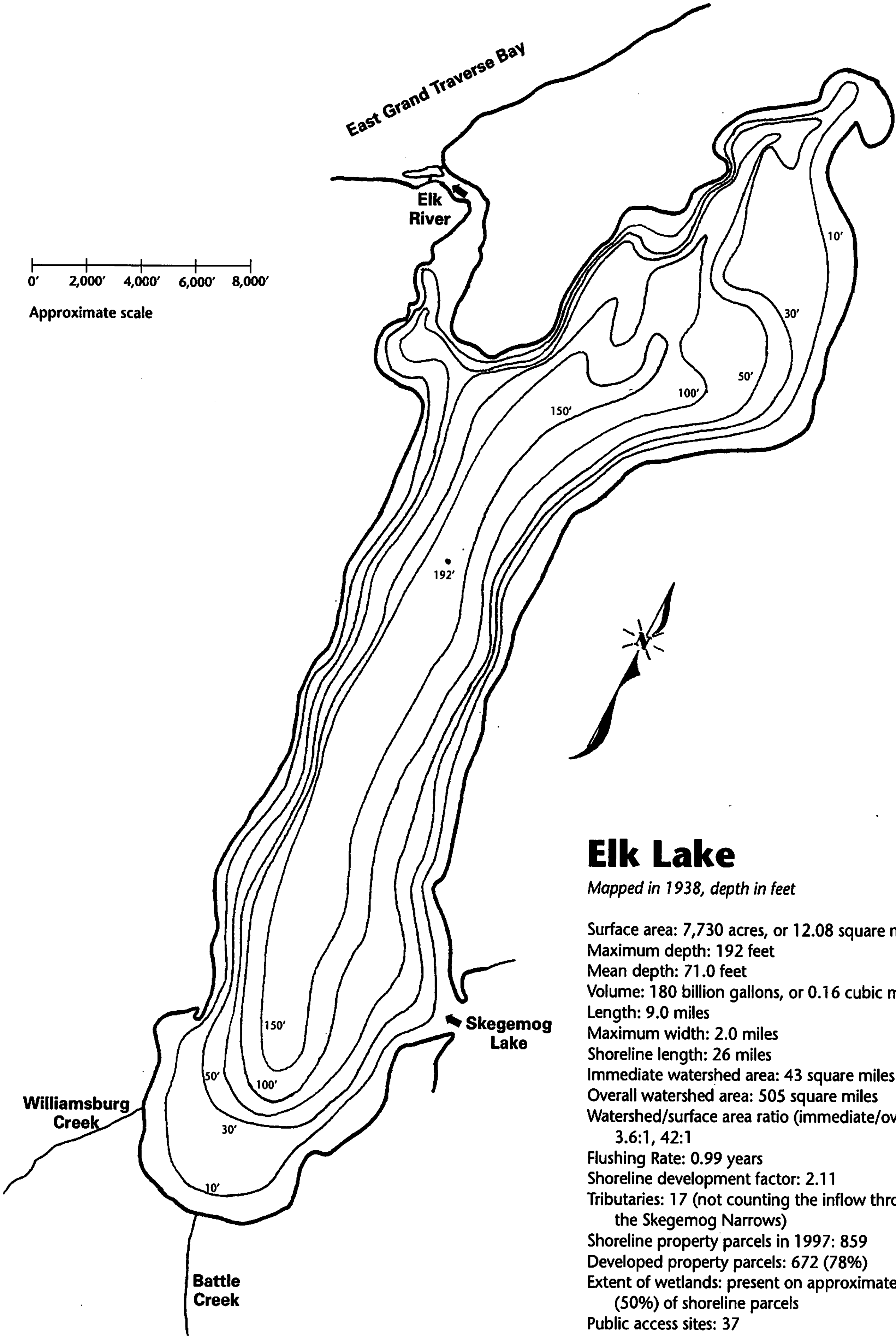
The MDNR has conducted surveys of the lake 16 times: 1932 ("general"), 1957-1965 (aerial ice fishing survey), 1956 (gill net, seine haul, and hook and line), 1971 (trap and fyke net), 1978 (boom electroshocker and trap net), 1982-1984 (aerial ice fishing survey), and 1996 (gill and trap nets).

Skegemog Lake

Mapped in 1931, depth in feet

Surface area: 2,560 acres. Or 4.0 square miles
Maximum depth: 29 feet
Mean depth: 12.4 feet
Volume: 10.3 billion gallons
Length: 3.7 miles
Maximum width: 1.8 miles
Shoreline length: 11.0 miles
Immediate watershed area: 187 square miles
Overall watershed area: 462 square miles
Watershed/surface area ratio (immediate/overall): 47:1, 116:1
Flushing Rate: 24 days
Shoreline development factor: 1.55
Tributaries: 6
Shoreline property parcels in 1997: 187
Developed property parcels: 149 (80%)
Extent of wetlands: present on approximately 138 (74%) of shoreline parcels
Public access sites: 11





Elk Lake

Mapped in 1938, depth in feet

Surface area: 7,730 acres, or 12.08 square miles
Maximum depth: 192 feet
Mean depth: 71.0 feet
Volume: 180 billion gallons, or 0.16 cubic mile
Length: 9.0 miles
Maximum width: 2.0 miles
Shoreline length: 26 miles
Immediate watershed area: 43 square miles
Overall watershed area: 505 square miles
Watershed/surface area ratio (immediate/overall): 3.6:1, 42:1
Flushing Rate: 0.99 years
Shoreline development factor: 2.11
Tributaries: 17 (not counting the inflow through the Skegemog Narrows)
Shoreline property parcels in 1997: 859
Developed property parcels: 672 (78%)
Extent of wetlands: present on approximately 426 (50%) of shoreline parcels
Public access sites: 37

Volunteer Monitoring on the Chain of Lakes

The Tip of the Mitt Watershed Council coordinates several water quality monitoring programs. One program, called Volunteer Lake Monitoring (VLM) utilizes volunteers to collect information at frequent intervals throughout the summer on water clarity and chlorophyll-a. The results are used to calculate something called a trophic status index (TSI), which provides information on how productive a lake is (See Chapter Two for more information on water clarity, chlorophyll-a, productivity, and trophic status). TSI values of 0-38 indicate an oligotrophic lake (one with clear, excellent quality water, but low productivity), 39 to 49 is mesotrophic (medium productivity, good quality), and 50 to 100 is eutrophic (often cloudy and weedy, productive for fishing, but generally considered poorer quality otherwise). TSI's are valuable when compared over time, because they can indicate if a lake is being polluted with nutrients or "aging." It is also interesting to compare the results from one lake to another. In theory, lakes with a high TSI should be able to support more fish than a lake with a low TSI. The following table shows the 1997 VLM results for seven lakes of the Chain, and East Grand Traverse Bay.

Recent VLM Results for the Chain of Lakes Area

LAKE	TSI	Avg. Summer Clarity (Feet)	Max. Summer Clarity (Feet)	Min. Summer Clarity (Feet)	Avg. Chlorophyll-A (parts per billion)
Six Mile	43	7.4	9.0	6.5	1.93
Intermediate	36	17.8	28.0	7.5	0.92
Clam	38	9.5	10.5	8.5	1.06
Bellaire	33	11.5	12.5	10.0	0.46
Torch	24	26.0	38.0	16.0	0.30
Skegemog	37	11.0	14.0	8.5	1.07
Elk	31	16.0	26.0	12.5	0.46
East Grand Traverse Bay	25	38.5	47.5	32.5	0.35

Fish species identified during the various surveys include walleye, rock bass, largemouth and smallmouth bass, white sucker, yellow perch, bluegill, brown and rainbow trout, bullhead, channel catfish, northern pike, longnose gar, Great Lakes muskellunge, cisco, pumpkinseed sunfish, and rosyface and golden shiner.

Bass were planted in 1932, perch were planted in 1933, and Great Lakes muskellunge were planted in 1990 and 1994.

The 1956 survey found that much of Skegemog's bottom is covered with pondweeds, water milfoil, water naiad, wild celery (or tapegrass), and muskgrass (or Chara). This is similar to what was observed during the 1997 shoreline survey by the Watershed Council. Results of the 1996 MDNR survey are similar to those obtained during the 1978 trap netting survey. Good populations of smallmouth bass and rock bass are present. Efforts are being made to identify and protect critical Great Lakes muskellunge habitat. Some anglers report catching walleye, but they are apparently not very abundant.

Elk Lake and the Elk River

Elk Lake is the last lake in the Chain, positioned between Skegemog Lake and East Grand Traverse Bay. It discharges into East Bay via the Elk River.

Flow-wise, the Elk River is fairly large (the annual average flow is about 763 CFS), but it is extremely short. A dam was first constructed on the river in the 1860's. The present dam raises the water level in Elk and Skegemog Lakes about five feet above pre-dam conditions (judging by the depth to which submerged stumps are found in places), and impounded most of the original river channel. Now the only portion that really resembles a river is a 600-foot stretch below the dam. The water behind the dam is about eleven feet above the level of the Bay (the legal summer and winter levels are 590.8 feet and 590.2 feet respectively, compared to Lake Michigan's average elevation of about 579 feet).

The flooded tree stumps in Spencer Bay just west of U.S. 31 resulted from the damming–anytime trees or stumps are found in permanently ponded areas, it is a sign of damming or another type of hydrological disturbance. When the water is very clear, it is possible to look down through the water almost half a mile upstream of the dam and view the flooded river channel and its rocky bottom, which, as the name implies, was a rapids at one time. The dam blocks fish migration between the Chain of Lakes and Lake Michigan, unfortunately excluding native migratory species, but also keeping exotic species and the toxins carried in Great Lakes fish out of the Chain. It still produces hydroelectric power.

Elk Lake is Michigan's 14th largest lake. It is an oligotrophic lake (nutrient poor). High levels of calcium carbonate in its waters impart a characteristic emerald green color in summer.

Public access sites include an MDNR boat launch, county and township parks, many road endings and pedestrian access easements, and numerous parcels owned by the Grand Traverse Regional Land Conservancy.

Especially extensive, important wetlands are found on the northeast shore near Kewadin, and on the south end adjacent to Battle Creek.

Most of the nearshore bottom sediments of Elk Lake (54%) are a mixture of sand, gravel, and rocks. This is a reflection of its large size and waveswept shorelines. Sand is predominantly found at 44% of shorelines (mostly at the lake's north and south ends), while soft bottoms are found at only 2% of shorelines (mostly in sheltered areas along the Kewadin wetlands and in portions of Spencer Bay near the outlet).

Because of Elk Lake's oligotrophic

Fish Species Collected in Elk Lake

Longnose gar
Common shiner
Blacknose shiner
Sand shiner
Creek chub
Northern redbelly dace
Rosyface shiner
Bluntnose minnow
Blacknose dace
Longnose dace
White sucker
Bullhead sp.
Catfish sp.
Northern pike
Great Lakes muskellunge
Central mudminnow
Rainbow smelt
Lake herring or cisco
Lake whitefish
Rainbow trout
Splake
Brown trout
Brook trout
Lake trout
Burbot
Sculpin sp.
Rock bass
Pumpkinseed sunfish
Bluegill
Longear sunfish
Smallmouth bass
Largemouth bass
Black crappie
Iowa darter
Johnny darter
Logperch
Yellow perch

Results of a 1996 Creel Census on Elk Lake

In August, 1996, the MDNR conducted a creel census on Elk Lake in conjunction with the Elk Skegemog Lake Association (ESLA). The survey was in response to questions and concerns about whether the fishery was as good as it once was, and whether efforts to plant brown and rainbow trout are worthwhile or may possibly negatively affect the overall fishery. The MDNR helped design survey forms, which ESLA sent to shoreline residents and handed out at bait shops, marinas, party stores, etc. ESLA also conducted the boat counts necessary for statistical interpretation of the survey (only those fishing from boats were evaluated).

Although only 50 survey forms were returned, from them it was estimated that anglers made 3,860 fishing trips and spent 11,400 hours fishing. About 74% of anglers targeted bass and yellow perch, about 23% trout, and about 3% other panfish. A total catch of 6,016 fish was estimated during the month, with an overall catch rate of about 0.53 fish per hour. Yellow perch had the highest individual catch rate (0.25 fish per hour of effort), compared with about 10 hours of effort per lake trout.

Although a more extensive creel survey is needed to better assess the characteristics of Elk Lake's sport fishery, and in particular to assess the effectiveness of trout planting, MDNR biologists felt that the 1996 study provided good baseline information.

status and absence of soft sediments conducive to aquatic plant growth, aquatic plants are not common. About 86% of the shoreline has little or no aquatic plant growth. The most common plants are muskgrass (or Chara) and sago pondweed, which are present at about 13% of properties. Sixty-three sites showed signs of accelerated erosion on Elk and Skegemog Lakes. This is the highest incidence of erosion on any of the lakes of the Chain, probably as a result of the increased water level by the Elk Rapids Dam.

Elk Lake's named tributaries include Battle Creek and Williamsburg Creek.

The MDNR has conducted fish surveys on Elk Lake in 1891, 1923 ("general"), 1931 ("general"), 1956 ("general"), 1990 (gill net), and 1996 (creel census). The 1891 survey reported the presence of trout (species not noted, but probably lake trout), burbot, cisco, rock bass, northern pike, yellow perch, whitefish, and white sucker. The 1931 survey found smallmouth bass, yellow perch, and rock bass to be fairly abundant; while northern pike, largemouth bass, Great Lakes muskellunge, cisco, whitefish, lake trout, sucker, brown bullhead, and "numerous species of forage fish" were noted as being present. The sidebar lists all of the 37 species identified during the six MDNR surveys.

Not many brown or rainbow trout were captured during the 1990 gill net survey, even though good angler success for brown and rainbow trout was reported. Only one fin-clipped lake trout was found, indicating good natural reproduction. A 4 lb, 9 oz. whitefish was found to be 8 years old, and a 14 oz, 14.5" whitefish was found to be 4 years old.

Elk Lake is currently managed as a coldwater fishery. Natural recruitment of lake trout is considered moderate to good (which is why stocking was determined to be unneeded), and good to excellent natural populations of whitefish and cisco are present. Unfortunately, the lake trout in Elk Lake have high levels of polychlorinated bipheryls (PCBs, a widely-used industrial compound harmful to human health banned in 1977), and women and children are advised against eating more than one meal per week.

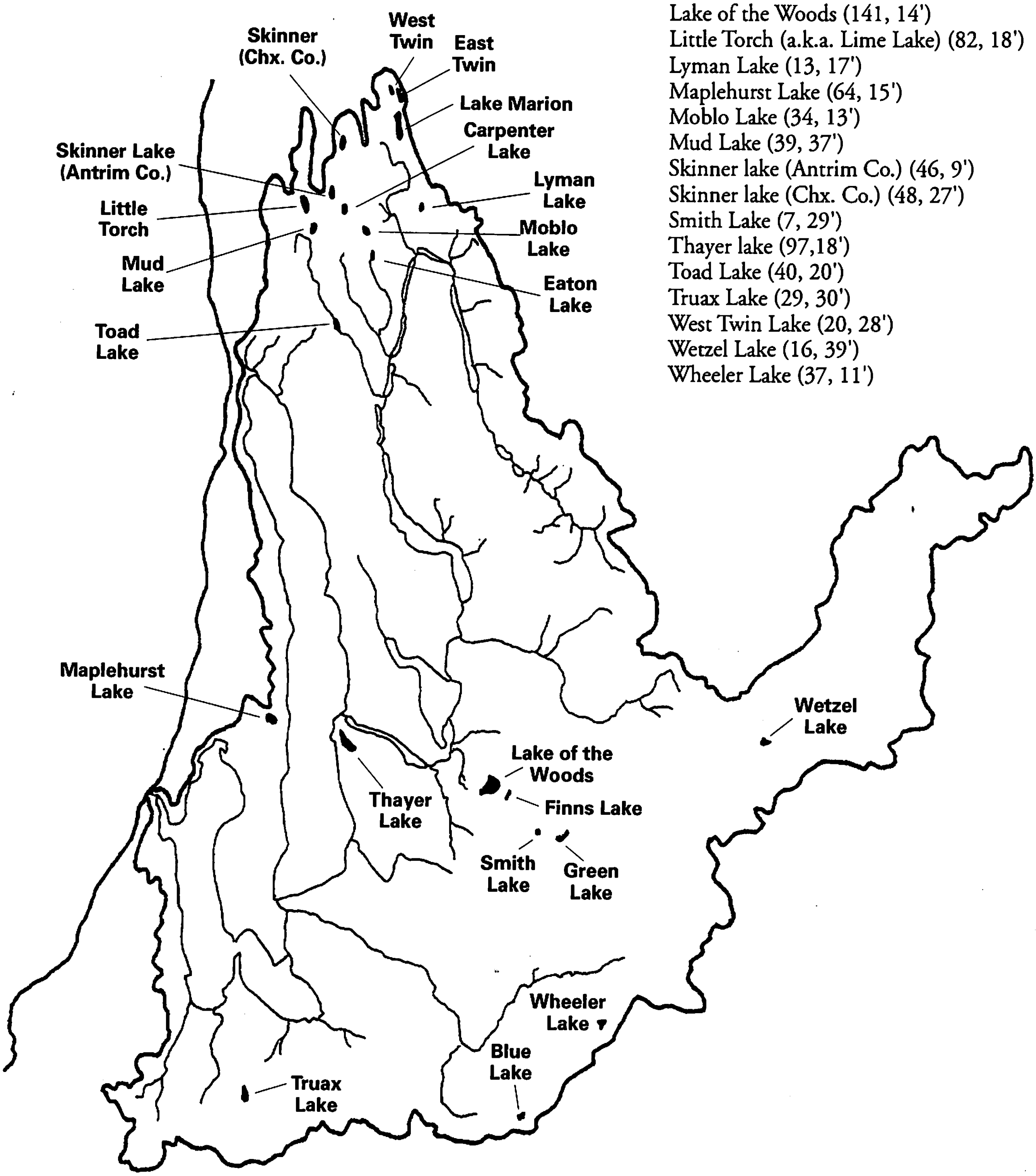
Lake trout, largemouth and smallmouth bass, walleye, yellow perch, and bluegill have all been planted at various times between 1894 and 1941. Between 1939 and 1984, lake, rainbow, and brown trout, and splake were all planted. Since 1984 only brown and rainbow trout have been planted. Most recently, Elk Lake received 25,000 brown trout in 1997 and 59,000 rainbow trout in 1998-99.

The MDNR has conducted fish surveys on the Elk River below the dam twice, in 1926 ("general") and 1960 (electroshocking for sea lamprey). The following species were found during the two surveys: blacknose, blackchin, sand, lake (emerald?), and common shiner; bluntnose minnow; sea lamprey; central mudminnow; johnny and Iowa darter; mottled sculpin; western banded killifish; pumpkinseed and longear sunfish; bluegill; rock bass; smallmouth and largemouth bass; nine spine stickleback; brown bullhead; and brook, lake, and rainbow trout. Significant runs of sea lamprey were first reported in the Elk River about 1940. In 1947, proposals to construct boat locks on the Elk River were considered. Fortunately, they were never built.

Other Lakes in the Elk River Watershed

Besides the Lakes of the Chain, there are many other lakes within the Chain of Lakes Watershed. Some of these lakes are connected to the Chain via tributaries, while others have no surface connection. Many have no public access. Some of the major lakes, and their acreage and maximum depth (in parenthesis), are shown on this map of the watershed.

Blue Lake (24,13')
Carpenter Lake (38, 30')
East Twin lake (48, 10')
Eaton Lake (23, 42')
Finn's Lake (14, 10')
Green Lake (40, 57')
Lake Marion (119, 52')
Lake of the Woods (141, 14')
Little Torch (a.k.a. Lime Lake) (82, 18')
Lyman Lake (13, 17')
Maplehurst Lake (64, 15')
Moblo Lake (34, 13')
Mud Lake (39, 37')
Skinner lake (Antrim Co.) (46, 9')
Skinner lake (Chx. Co.) (48, 27')
Smith Lake (7, 29')
Thayer lake (97,18')
Toad Lake (40, 20')
Truax Lake (29, 30')
West Twin Lake (20, 28')
Wetzel Lake (16, 39')
Wheeler Lake (37, 11')



Major Tributaries to the Chain of Lakes

Intermediate River

The Intermediate River flows into the southeast end of Beals Lake. The stream system has eight tributaries, including Hitchcock, Spence, Seamon, and Taylor Creeks. The most distant of these tributaries originates about six miles upstream of Beals Lake. From the perspective of distance of flow, this is the most distant of the ERCOL's tributaries—about 60 water miles upstream of the mouth of the Elk River (but only about 18 miles away by straight-line distance). The stream is located in Echo and Kearney Townships. It is shown on the Scotts Lake and Chestonia 7.5 minute U.S.G.S topographic maps (see sidebar).

The Intermediate River flows out of a 1,417 acre conifer swamp called Hitchcock Swamp, one of the largest, and reputedly most impenetrable, swamps in the area. The stream's waters have a slight tea-colored stain due to leaching of organic material from the swamp.

The greatest elevation of the river's headwater's is 812 feet. The stream drops 192 feet in elevation, for an average stream gradient of about 32 feet per mile per mile. Most of this gradient occurs within the upper few miles, where the stream originates in hilly terrain before flowing through the swamp.

There are large tracts of State and County land along the stream system. Old State Road is the only road which crosses the stream, just upstream from Beals Lake. Where it crosses the road, the stream is about 20 feet wide and one foot deep, with a sand and silt bottom. Its discharge is about 20 CFS.

Thermal characteristics of the stream indicate that it has moderately-high ground water inputs. The Intermediate River is designated as a trout stream by the MDNR. A stream survey was conducted in 1957. The stream was described as having slow velocity, a sand and gravel bottom, and "a reputation for poor trout fishing." Brook trout, minnows, and sucker were listed as being present. Brook trout were planted in 1953, 1956 and from 1959-1965, but it was decided that due to stable stream flows and excellent natural reproduction, stocking was not warranted.

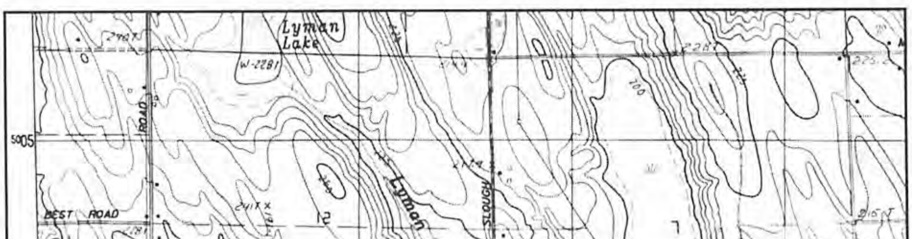


Figure 40 - A portion of the Ellsworth quadrangle, showing Lyman Lake, St. Clair Creek, St. Clair Lake, and the Village of Ellsworth.

Topographic Maps

Topographic maps (often called "topo" maps for short) are produced by the U.S. Geological Survey (USGS). They accurately represent the natural and constructed features of the land. The shape and elevation of the terrain are portrayed by contour lines, and specific features such as lakes, streams, wetlands, vegetation, roads, buildings, towns, and political boundaries are portrayed by symbols and colors (Figure 40). Topo maps are invaluable for cross-country navigation; delineating watershed boundaries; and understanding the nature of lands which drain to a particular lake, stream, or wetland body.

USGS topographgic maps are available in a series of sizes covering systematically subdivided areas of latitude and longitude. The standard size is the 7.5 minute quadrangle series, covering an area of six by nine miles with a scale of 1:24,000 (1 inch = 2,000 feet). Each map is named for a distinctive feature within it (such as the Alden or Torch River quadrangle). There are 14 topographic quadrangle maps which cover the Elk River Watershed.

Indexes of map coverage and maps are available from USGS Map Distribution, Federal Center, Building 41, Box 25286, Denver, CO, 80225 (303-236-7477). Michigan United Conservation Clubs is a quick source for topo maps (they take orders with a credit card over the phone: 1-800-777-6720). Sometimes, topo maps are available locally from stores that sell outdoor, hunting, or fishing supplies.

Wetlands and Why They Are Important

Throughout this chapter, reference is made to the amount of shoreline wetlands, and the most notable wetlands on each lake or stream. Wetlands are defined as areas where the soil surface is saturated long enough during the growing season so that wetland-tolerant plants dominate the vegetation community. Wetlands also usually have distinctive soil types. In other words, wetlands are a transition between dry uplands, and lakes and streams.

There are three general types of wetlands: marshes, swamps, and peatlands. Marshes include a broad array of wetlands that are dominated by herbaceous (non-woody) vegetation. Swamps are wetlands forested with trees (like cedar swamps) or shrubs (like willow or alder). Peatlands, commonly referred to as bogs or fens, have (as the name implies) thick deposits of a type of soil called peat. Peat consists of somewhat decomposed fibrous plant material which develops under very wet, cool conditions.

Wetlands are complex ecosystems that provide many ecological functions that directly benefit fish. A few fish species (e.g.central mudminnow) prefer to spend most of their life cycle in permanently ponded wetlands. Many fish spawn in wetlands, or spend their juvevile stages in wetland nurseries (northern pike being a prime example). Fish feed in wetlands or on food produced there which eventually makes its way into the water. Wetlands recycle nutrients back into lakes and streams, yet protect against pollution from excessive nutrients or other pollutants. Wetland vegetation prevents shoreline erosion in two ways. Emergent plants buffer shorelines against waves and currents, and the roots of woody vegetation strengthen shoreline soils. Wetland soils and floodplains protect against flooding by storing excess water and releasing it slowly. Most wetlands are sites of ground water discharge, and as such provide steady flows of high quality water to lakes and streams. This is especially important for maintaining the proper temperature of trout streams.

It is estimated that three-quarters of the fish production in the U.S. depends on marshes and other wetland environments. The disappearance of wetlands leads to the decline of fish which depend on them. Half of the Nation's original wetlands have already been destroyed, so it is logical to assume that the capability to produce fish has already been greatly diminished. To preserve what remains of our fisheries resources, it is essential to protect the remaining wetlands. For more information about wetlands, please refer to the Watershed Council's publication, *Living With Michigan's Wetlands: A Landowner's Guide.*

Vance Creek

Vance Creek discharges to Six Mile Lake, on its east side near the south end. The stream system has three tributaries, all of which are small and unnamed. The most distant of these tributaries originates about three miles upstream of Six Mile Lake. The stream is located in Echo Township. It is shown on the Scotts Lake 7.5 minute U.S.G.S topographic map.

Vance Creek originates in rolling uplands, some of which are forested and some of which are pasture or agricultural lands, before flowing through the relatively flat post-glacial lake plain surrounding the present shoreline of Six Mile Lake. The greatest elevation of the creek's headwaters is 886 feet. The stream drops 279 feet in elevation, for an average stream gradient of about 93 feet per mile per mile.

There is no public land along the stream. The stream system is crossed by Dingman School and Vance Roads. At Dingman School Road, the stream is about eight feet wide and six inches deep, with a sand/gravel bottom.

Quite a bit of ice forms on this stream in winter, indicating relatively little ground water input and therefore possibly poor habitat for trout and other fish. Vance Creek is not designated as a trout stream by the MDNR.

Liscon Creek

Liscon Creek delivers its flow into Six Mile Lake, on the east side near the north end. The stream system has five tributaries, only one of which is named (Ranney Creek). The stream is located in South Arm Township (Charlevoix County). It is shown on the Ellsworth 7.5 minute U.S.G.S topographic map.

The most distant tributary originates about three miles upstream of Six Mile Lake in rolling uplands, some of which are forested and some of which are pasture or agricultural lands. The last half mile flows through a large lakeside swamp. The greatest elevation of the creek's headwaters is 804 feet. The stream drops 196 feet in elevation, for an average stream gradient of about 65 feet per mile.

There is no public land along the stream. The stream system is crossed by Miles, Rogers and Ranney Roads. At Miles Road, the stream is about eight feet wide and six inches deep, with a sand/gravel bottom. The water is clear, but slightly stained. Base flow is estimated to be about four CFS. Thermal characteristics of the stream indicate that it has relatively high ground water inputs. Liscon Creek is not designated as a trout stream by the MDNR.

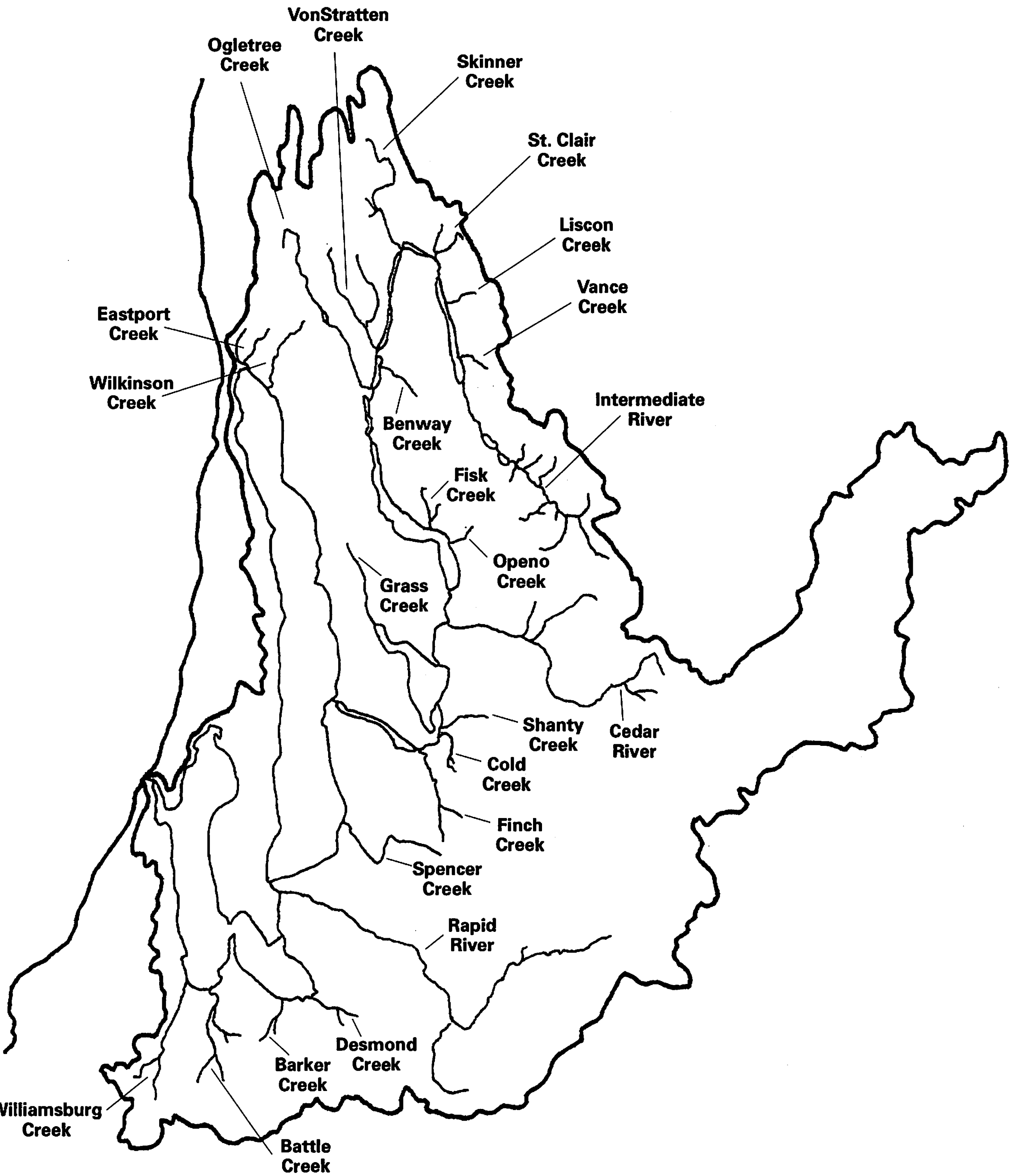
St. Clair Creek

St. Clair Creek is a tributary to the Sinclair River. The stream system has two tributaries, only one of which is named (Lyman Creek, which originates in a small inland lake, Lyman Lake). The most distant of these tributaries originates about 2.5 miles upstream of the Sinclair River. The stream system is located in Banks (Antrim County) and South Arm (Charlevoix County) Townships. It is shown on the Ellsworth 7.5 minute U.S.G.S topographic map (Figure 40).

Most of the St. Clair Creek system originates in swampy areas, some of which are quite large. The greatest elevation of the creek's headwaters is 656 feet. The stream drops 54 feet in elevation, for an average stream gradient of about 21 feet per mile.

The area at the mouth of the stream is protected as part of the St. Clair-Six Mile Lakes Natural Area, and open for public use. Otherwise, there is no

Figure 41 – Major Tributaries to the Chain of Lakes



Blue Ribbon Trout Streams

Michigan has over 38,000 miles of rivers and streams. Of these, about 1/3 (12,500 miles) are classified as trout streams. Forty-nine streams, or portions of streams, totaling 874 miles (or only about 2% of Michigan's stream miles) are considered premier, top-quality trout streams which Michigan classifies as its Blue Ribbon Trout Streams (BRTS).

A BRTS must meet certain standards or criteria. It must:

- Be one of Michigan's best trout streams,
- Be able to support excellent stocks of wild, resident trout,
- Have the physical characteristics to permit fly casting but be shallow enough to wade,
- Produce diverse insect life and fly hatches,
- Have earned a reputation for providing excellent (quality) trout fishing, and,
- Have excellent water quality.

Management of BRTS by the MDNR is directed toward accommodating the needs of trout anglers, maintaining strong stocks of wild, resident trout that best suit the character of each stream, maintaining and enhancing trout habitat and the natural stream environment, providing adequate public access and public frontage, and preparing appropriate informational materials on these special streams. A brochure identifying Michigan's blue ribbon trout streams is available from the MDNR.

public land along the stream. Ellsworth, Detour, Slough, and Miles Roads cross this stream or its tributaries. At Ellsworth Road, just upstream from its mouth, the stream is about 10 to 12 feet wide and four to 12 inches deep with a sand-silt bottom.

The stream is clear and slightly stained. The channel flows through a hardwood swamp, and is densely shaded. Estimated base flow is about five CFS. Thermal characteristics of the stream indicate that it has moderately-high ground water inputs. St. Clair Creek is not designated as a trout stream by the MDNR.

Skinner Creek

Skinner Creek flows into the Intermediate River between St. Clair and Ellsworth Lakes. The stream system has eight tributaries, only one of which is named (Marion Creek). The most distant of these tributaries originates about eight miles upstream of the creek's mouth. Marion Creek is about five miles long.

Skinner Creek originates from Skinner Lake in Banks Township. The stream then flows north through another lake (also called Skinner Lake) in Marion Township, Charlevoix County, before turning south again and flowing through swampy interdrumlin swales back into Banks Township. The stream is shown on the Atwood and Ellsworth 7.5 minute U.S.G.S topographic maps.

The greatest elevation of the creek's headwaters is 764 feet. The stream drops 156 feet in elevation, for an average stream gradient of about 20 feet per mile.

There is no public land along the stream. The stream system is crossed by roads many times, including Ellsworth, Best, Atwood, and Eaton Roads. At Best Road, the stream is about eight feet wide and seven inches deep. The bottom is mostly sand, with some areas of gravel and rocks. The water is slightly stained, and frequently has slight turbidity from suspended sediment (possibly from agricultural runoff—see sidebar). The stream flows through an alder swamp in this area. Estimated stream flow is about 10 CFS.

Thermal characteristics of the stream indicate that it has moderately-high ground water inputs. As the stream flows through the town of Ellsworth, urban surface runoff degrades the water quality somewhat. Skinner and Marion Creeks are designated as trout streams by the MDNR (as is another part of the Skinner Creek system referred to as Mason Creek on the list). The MDNR has surveyed Skinner Creek twice, in 1927 and 1957. The survey reports referred to it as Orr Creek. Brook trout and minnows were found to be present. The stream was described as having clear water, sand and gravel bottom, medium velocity, and good brook trout fishing.

Von Stratten Creek

Von Stratten Creek discharges into Wilson Lake, at its southwest end. The stream system has six tributaries, only one of which is named (Kings Creek). Von Stratten Creek is about seven miles long, and Kings Creek is about four miles long. The stream is located in Banks and Central Lake Townships of Antrim County. It is shown on the Ellsworth, Central Lake, and Atwood 7.5 minute U.S.G.S topographic maps.

Von Stratten Creek originates in Moblo and Eaton Lakes. It flows through forested and agricultural landscapes. The greatest elevation of the creek's headwaters is 787 feet at Moblo Lake. The stream drops 161 feet in elevation, for an average stream gradient of about 23 feet per mile.

There is no public land along the stream. The stream system is crossed by roads eight times, including crossings by Ellsworth, Essex, and Dennis Roads.

Near the confluence of Von Stratten and Kings Creeks, just east of Ellsworth Road, the stream is about four feet wide and six to eight inches deep, with a sand bottom. The water is clear and slightly stained. Estimated base streamflow is three CFS. The stream flows through a narrow alder swamp in this area. Thermal characteristics indicate that Von Stratten Creek has moderately-high ground water inputs, and that Kings Creek has low levels of ground water input. Von Stratten Creek is not designated as a trout stream by the MDNR. Stream surveys were done on this system in 1926 and 1941. Those reports referred to different portions of the stream as either Townline, Mabel, or Benway Creek. They described a swift flow; sand, gravel or mud bottom; brown-stained water; and scarce brook trout.

Figure 42 - Ogletree Creek just upstream of Benway Lake.

Ogletree Creek

Ogletree Creek delivers its flow into Benway Lake, near the Lake's outlet. Ogletree Creek originates from Little Torch Lake, where it is called Toad Creek. Toad Creek flows through two other lakes, Mud Lake and Toad Lake. It is called Ogletree Creek after discharging from Toad Lake. The stream is located in Antrim County's Central Lake and Banks Townships. It is shown on the Atwood and Central Lake 7.5 minute U.S.G.S topographic maps.

Ogletree and Toad Creeks have a combined length of about 11 miles. The stream system has four tributaries, only one of which is named (Kitty Ann Creek). The streams flow mostly through a wooded corridor, and pass through some large tracts of swampland. The greatest elevation of the creek's headwaters is 728 feet. The stream drops 121 feet in elevation, for an average stream gradient of about 11 feet per mile.

There is no public land along the stream. The stream system is crossed 13 times by roads, including crossings by Chessie Lane (near its mouth), and Ellsworth, Atwood, and Essex Roads.

Thermal characteristics of the stream indicate that it has low to moderate ground water inputs, depending on the location along the stream system. At Chessie Lane, the stream is about 20 feet wide and one foot deep, with a sand bottom (Figure 42). The stream is clear and slightly stained. Estimated average streamflow is 11 CFS. Ogletree Creek is designated as a trout stream by the MDNR. MDNR surveys in 1926 and 1941 described the stream as being swift with brown-stained water and a sand, gravel, or mud bottom. Brook trout were observed.

Benway Creek

Benway Creek is a tributary to Benway Lake on its east side. The stream system has two tributaries, none of which are named. The most distant of these tributaries originates about three miles upstream of Benway Lake. The stream is located in Central Lake Township (Antrim County). It is shown on the Central Lake and Scotts Lake 7.5 minute U.S.G.S topographic maps.

Benway Creek's watershed is mostly forested. It originates in forested rolling uplands at an elevation of 918 feet. The stream drops 311 feet in elevation, for an average stream gradient of more than 100 feet per mile. There is no public land along the stream. The stream system is crossed by Rushton and Mohrman Roads.

At Rushton Road, the stream is about two to three feet wide and four to six inches deep, with a sand-silt bottom. Estimated streamflow is two CFS. The stream's water is slightly stained and clear. Thermal characteristics of the stream indicate that it has moderately-high ground water inputs. Benway Creek is not designated as a trout stream by the MDNR.

Fisk Creek

Fisk Creek flows into the east side of Intermediate Lake. The stream system has one unnamed tributary. The stream's headwaters originate about 2.5 miles upstream of the Lake, in hilly, wooded terrain. The stream flows through Mohrman County Park, and several other tracts of land owned by Antrim County. The stream is located in Echo, Central Lake, and Kearney Townships (Antrim County). It is shown on the Scotts Lake 7.5 minute U.S.G.S topographic maps.

The greatest elevation of the creek's headwaters is 781 feet. The stream drops 173 feet in elevation, for an average stream gradient of about 70 feet per mile. The stream system is crossed by Intermediate Lake and Muckle Roads.

At Intermediate Lake Road, the stream is about five feet wide and varies from about two to 16 inches in depth, with a gravel-sand-silt bottom. Estimated streamflow is 2.5 CFS. The stream's water is slightly stained and clear. Thermal characteristics of the stream indicate that it has moderately-high ground water inputs. Fisk Creek is designated as a trout stream by the MDNR (although their list refers to it as Fish Creek). A "stream examination" was conducted in 1926, at which time it was referred to as Mohrman Creek. The report described the stream as being four feet wide and six inches deep, with a sand and gravel bottom and abundant brook trout.

Openo Creek

Openo Creek discharges to Intermediate Lake, on the east side near the south end. The stream system has one unnamed tributary. It originates about three miles upstream from its mouth in hilly terrain, which is partly wooded and partly open. The stream is located in Kearney and Echo Townships (Antrim County). It is shown on the Scotts Lake 7.5 minute U.S.G.S topographic map.

The greatest elevation of the creek's headwaters is 978 feet. The stream drops 371 feet in elevation, for an average stream gradient of about 125 feet per mile. There is no public land along the stream. There are a number of private ponds associated with the stream along its length.

The stream system is crossed by Intermediate Lake, Derenzy, and McKinney Roads. At Intermediate Lake Road, the stream is about two to three feet wide and four to 12 inches deep, with a sand-gravel bottom. This is one of the smallest named streams in the Elk River Watershed, with an estimated streamflow of only about one CFS. The stream's water is slightly stained and clear. Thermal characteristics of the stream indicate that it has moderately-high ground water inputs. It is not designated as a trout stream by the MDNR. MDNR surveyed Openo Creek in 1932. At that time it was described as having a swift current, an average width of three feet, and a sand and gravel bottom. Many brook trout were seen. In spite of that, brook trout were planted here in 1947 and 1949.

Cedar River

The Cedar River delivers its flow into the Intermediate River just upstream from Bellaire. The mainstream of the Cedar originates about 14 miles upstream of the stream's mouth in swampy areas at the base of high, forested moraines. The stream is located in Kearney, Chestonia, and Custer Townships, Antrim County. It is shown on the Bellaire and Mancelona 7.5 minute U.S.G.S. Topographic maps.

The stream system has 12 tributaries, three

Figure 43 - Biologists from the Grand Traverse Band use backpack electroshockers to assess the fish population of the Cedar River.

Development Causes Problems and Controversy for the Cedar River

In 1997, nearby Shanty Creek Resort proposed to increase its irrigation water withdrawal from the Cedar River to as much as 18% of the base flow and construct a new golf course in close proximity to the stream, with several holes proposed to cross the river. The Friends of the Cedar River, a grassroots advocacy/protection group, was formed in response to Shanty Creeks's development proposal. They initiated a court case to stop the proposal. Eventually, an out-of-court settlement was reached agreeing that:

1. Golf holes would not cross the river, leaving an intact cedar swamp river corridor,
2. Water withdrawal for irrigation would continue, but would ultimately be lower than historically allowed levels,
3. Effective stormwater management techniques would be installed, and,
4. Biannual monitoring of the river's habitat and water quality would be conducted.

In August, 1998, a heavy rainstorm occurred, with 2.5 inches of rain recorded in some localities. There was massive runoff and erosion from the golf course under construction, with an estimated 55 tons of soil and large volumes of runoff flowing into the Cedar River. Immediately following the storm, the site was inspected by staff from the Antrim Conservation District, MDNR Fisheries Division, and MDEQ Surface Water Quality Division (SWQD). Sedimentation, channel alteration, and streambank erosion were evident. One week later, SWQD staff conducted a habitat assessment and documented that changes to the stream channel and bed had occurred, although a fisheries survey found that the event did not appear to have caused any short-term damage to the fish population. Eventually, Shanty Creek agreed to pay for expensive stream restoration and install more stringent stormwater and erosion control measures to ensure that similar problems would not occur again.

of which are prominent enough to be named (North Branch of the Cedar, Wolcott Creek, and Scotts Springs). The Cedar is classified as a fourth-order stream (see Figure 19).

There is presently one dam on the river, located on the outskirts of Bellaire. It was built in 1906 and impounds a small water body known as Craven Pond (but which has also been referred to as Blair or Bellaire Pond). There was formerly another dam upstream which created an impoundment known as Stover Pond. However, the Stover Pond Dam washed out in 1961, resulting in serious damage to the stream and its corridor.

The stream system is crossed nine times by roads: East Jordan-Mancelona Rd. (M-66) nearest its headwaters, followed by Cedar River Rd., Cedar River Dr., Schuss Mt. Rd. (twice), Stover Pond Rd., Graham Rd., Burrell Rd., and, nearest the mouth, Derenzy Rd. (C- 620).

The elevation of the river's headwaters is 920 feet. The stream drops 311 feet in elevation by the time it reaches the Intermediate River, for an average stream gradient of about 22 feet per mile. However, a four mile stretch of the river along Schuss Mountain Road has a average gradient of about 43 feet per mile. With such a steep gradient for a relatively large stream, the Cedar has a swift, powerful current. This results in a mostly gravelly or rocky bottom, but sand collects in some areas of flatter gradient.

The average width is approximately 20 feet, with holes reaching four feet deep. The corridor is mostly an undeveloped cedar swamp, with many overhanging trees, and logs and other woody debris in the water. There is little aquatic vegetation. The water is clear and unstained. Underwater rocks and logs have thick, crusty coatings of marl, indicating high hardness and alkalinity. A hydrologic study in 1993 determined that the Cedar River's average annual flow at its mouth is about 94 CFS.

There is not much public land along the Cedar. Besides the road-stream crossings, the stream can be accessed at the Village of Bellaire's Craven Park (on Craven pond), at five small separate parcels of State land (the largest of which is in the area of the former Stover Pond), and on a preserve owned by the Michigan Nature Association.

The stream was surveyed in 1927, 1932, 1957, 1966, 1977, 1978, and 1998 by the MDNR. The 1927 survey reported many brook trout and "muddlers" (mottled sculpin). In 1978, the stream was surveyed above and below the old Stover Pond dam site. Downstream, 11 brook trout (up to 6" long), 124 brown trout (up to 18" long), 58 mottled sculpin, and one lone pumpkinseed sunfish were captured. White Sucker were also apparently present. Upstream (at Cedar River Drive) 159 brook trout (up to 9" long), 19 brown trout (up to 19" long), 165 mottled sculpin, and three brook stickleback were captured. Water temperature was 58° F., while air temperature was in the 70s.

The conclusion was that there was an excellent brook trout fishery above Stover Pond, although growth was generally found to be a little below the state average. Fishing pressure was judged to be heavy in places. After the dam washed out, there was some concern that upstream movement of brown trout would displace brook trout.

A habitat assessment conducted in the vicinity of a then-proposed golf course (see sidebar) by the Watershed Council in 1998 found that in-stream habitat, channel morphology, and structural features all rated excellent.

In 1999, an electroshocking survey was conducted by the Natural Resources Department of the Grand Traverse Band of Ottawa and Chippewa Indians (Figure 43). Several portions of the stream were surveyed, and 119-242 fish, weighing 12-31 pounds per acre, were captured. Fish were not marked and recaptured as necessary to accurately estimate the standing stock, but the results indicate "relatively good" numbers of fish. Similar to what the MDNR found in 1977-78, the growth was considerably lower than state averages. The slow growth was attributed to low summer water temperatures. The survey also found normal water quality and invertebrate community structure, resulting in an excellent rating for the stream.

Regular stocking of the Cedar occurred as early as 1938, but was stopped in 1966 with the realization that natural reproduction is not a limiting factor to the trout population. However Craven Pond has been routinely planted with brook and brown trout since 1955. Since 1990, the pond has been planted with several thousand brown trout annually.

In 1987-88, grayling were planted in the Cedar River (3,000 each year), as well as six other streams and 13 lakes in an effort to reintroduce them to Michigan. Most disappeared within six months, probably due to competition from resident fish, predation, and downstream migration. A few were caught by anglers soon after planting. Statewide, the reintroduction effort failed.

A gill net survey of Craven Pond in 1997 by the MDNR captured 18 brown trout (up to 16"), 2 rock bass, and 43 white sucker. Yellow perch, pumpkinseed sunfish, and minnows were also observed. Craven Pond is considered to provide excellent brown trout fishing. The Cedar River (including Craven Pond and all the river's tributaries) is on the MDNR's list of designated trout streams. In addition, it is the only stream in the Elk River Watershed to be designated a Blue Ribbon Trout Stream (see sidebar).

Grass Creek

Grass Creek is a tributary to the North Arm of Lake Bellaire. The stream system has only one tributary, which is unnamed. Grass Creek is about five miles long, and flows through large swampy areas. The stream is located in Forest Home Township (Antrim County). It is shown on the Alden and Central Lake 7.5 minute U.S.G.S. topographic maps.

The greatest elevation of the creek's headwaters is 820 feet. The stream drops 228 feet in elevation, for an average stream gradient of about 46 feet per mile.

The land along the creek between M-88 and the Lake is owned by the Grand Traverse Regional Land Conservancy, and is open to the public. However, there is no other public land along the stream. The stream system is crossed by Bellaire Highway; and Eckhardt, Honey Hollow, and Davock Roads.

At Bellaire Highway, the stream is about seven feet wide and four inches deep. The bottom is mostly sand, but there are areas of both silt and gravel. Thermal characteristics of the stream indicate that it has moderately-high ground water inputs. Estimated streamflow is about 2.5 CFS. The stream's water is slightly stained and clear. It is not designated as a trout stream by the MDNR.

Shanty Creek

Shanty Creek flows into the Grass River. According to the U.S.G.S. topographic map, the stream system has no tributaries. The stream originates about 2.75 miles above its mouth in forested uplands on the Shanty Creek Resort property. The lower quarter-mile of the stream flows through a streamside-swamp, a portion of which is part of the Grass River Natural Area and open to the public. The stream is located in Custer Township (Antrim County). It is shown on the Bellaire 7.5 minute U.S.G.S. topographic map.

The greatest elevation of the creek's headwaters is 738 feet. The stream drops 146 feet in elevation, for an average stream gradient of about 53 feet per mile. The stream system is crossed by Scenic Highway (M-88). At M-88, the stream is about eight feet wide and one foot deep, with a sand bottom. Estimated streamflow is 12 CFS. The stream's water is unstained and normally clear. Thermal characteristics of the stream indicate that it has high levels of ground water inputs. Shanty Creek is designated as a trout stream by the MDNR.

Both Shanty Creek and a small tributary (called Golf Links Creek) were surveyed by the MDNR in 1932. The stream was described as having cold, clear, swift water; a clean washed sand and gravel bottom about 25% covered by chara, moss, algae, and watercress; many logs; but very few brook trout. Construction of dams and encouragement of beavers was recommended (much different management recommendations than are accepted today!). Brook trout were planted in 1933, 1937, and 1939.

An environmental survey conducted by the Grass River Natural Area in 1984 found that the mean monthly stream temperature never rises above 68 degrees F. and that fast, turbulent flow conditions generally prevail. Brook, brown, and rainbow trout; and sculpins were found to dominate the upper reaches of the Creek. The rainbows found here are most likely the young of migratory rainbows (steelhead) from Torch or Elk Lakes. Aquatic mosses and filamentous algae were abundant and Elodea, water cress, and white water crowfoot were present.

Cold Creek

Cold Creek discharges to the Grass River. The topographic map does not show the stream as having tributaries, but ponds located adjacent to the stream indicate that some small ones may exist. The stream originates about 2.5 miles upstream of its mouth, at the base of forested moraines. The lower part of the stream flows through a large swamp, and discharges into the Grass River not far from the mouth of Shanty Creek. The stream is located in Custer Township, Antrim County. It is shown on the Bellaire 7.5 minute U.S.G.S topographic map.

The greatest elevation of the creek's headwaters is 640 feet. The stream drops 40 feet in elevation, for an average stream gradient of about 19 feet per mile. The lower portion of the stream flows for about half a mile through the Grass River Natural Area. The stream system is crossed by Alden Highway, and Comfort and Tyler Roads.

At Comfort Road, the stream is about ten feet wide and 18″ feet deep. The bottom is mostly sand with some gravel. There is a lot of in-stream woody debris, and the stream has many stable undercut banks. Estimated streamflow is about 20 CFS. The stream water is unstained and clear. As the name implies, Cold Creek is known for having steady, low summer temperatures due to high levels of ground water input. The observed temperature range throughout the year is 38 to 60° F.

An environmental survey was conducted by the Grass River Natural Area in 1984. The survey found that fast, turbulent flow conditions generally prevail. Brook, brown, and rainbow (young steelhead) trout; and sculpins were found to dominate the upper reaches of the creek. Bluntnose minnows were found where Cold Creek empties into the Grass River. Aquatic mosses and filamentous algae were abundant and white water crowfoot and wild celery (or tapegrass) were present.

Cold Creek is designated as a trout stream by the MDNR. A stream survey was conducted by the MDNR in 1957. The stream was found to have a "good, stable flow," slow velocity, a sand and gravel bottom, and "exceptionally cold water." Brook trout, suckers, and minnows were listed as being present. Brook trout were planted in Cold Creek in 1947, 1950, 1956, and 1959 to 1965. Plantings stopped in 1966 with the realization that there was sufficient natural reproduction to support a trout fishery.

Finch Creek

Finch Creek primarily flows into the lower Grass River, not far upstream from Clam Lake, although a divergent channel near its mouth flows directly into Clam Lake. The stream system has two tributaries, only one of which is named (Crow Creek). The most distant of these tributaries originates about 6.5 miles upstream of the stream mouth. The stream is located in Helena and Custer Townships (Antrim County). It is shown on the Bellaire and Leetsville 7.5 minute U.S.G.S topographic maps.

Finch Creek originates in a swamp between high moraines, not far from the headwaters of Spencer Creek (which flows into Torch Lake). The last half mile of the stream flows through a swampy area within the Grass River Natural Area. There is no other public land along the stream.

The greatest elevation of the creek's headwaters is 1,034 feet. The stream drops 443 feet in elevation, for an average stream gradient of about 68 feet per mile. The stream system is crossed by Alden Highway (C-618), and Finch Creek, Elder, and Bebb Roads.

At Alden Highway, the stream is about 20 feet wide and one to three feet deep, with a sand bottom. There are quite a few logs and other woody debris in the stream. The stream has many stable undercut banks. Watercress grows abundantly along the edges, and underwater rocks and logs are covered with aquatic moss. The stream's water is unstained and clear, except when road surface runoff from Finch Road causes cloudiness. Estimated streamflow is about 30 CFS. Thermal characteristics of the stream indicate that it has high levels of ground water input. Finch Creek is designated as a trout stream by the MDNR.

An environmental survey conducted by the Grass River Natural Area in 1984 found that the mean monthly stream temperature never rises above 68 degrees and that fast, turbulent flow conditions generally prevail. Brook, brown, and rainbow (yount steelhead?) trout; and sculpins were found to dominate the upper reaches of the Creek, with central mudminnow being found in some backwater areas. Abundant and diverse invertebrate fauna were documented, possibly due to the presence of abundant woody debris. Grayling were planted in Finch Creek in 1936 in a failed attempt to reintroduce the species to Michigan, and brook trout were plated in 1947 and 1950.

Eastport Creek

Eastport Creek is a tributary to Torch Lake at its northern end. The stream system has two unnamed tributaries. The longest of these tributaries is about four miles long. One branch of Eastport Creek originates in swampy interdrumlin swales, and another in a swampy lake plain near Lake Michigan. A short portion of the stream flows through Antrim County's Barnes Park, otherwise there is no public land along the stream. The stream is located in Banks and Torch Lake Townships (Antrim County). It is shown on the Atwood and Central Lake 7.5 minute U.S.G.S topographic maps.

The greatest elevation of the creek's headwaters is 820 feet. The stream drops 229 feet in elevation, for an average stream gradient of about 57 feet per mile. The stream system is crossed by U.S. 31, Scenic Highway (M-88), and Lore and Ferrel Roads.

At M-88, the stream is about six feet wide and six inches deep, with a sand-gravel bottom. Thermal characteristics of the stream indicate that it has moderately-high ground water inputs. Estimated streamflow is about three CFS. The stream's water is slightly stained and clear. Eastport Creek is designated as a trout stream by the MDNR.

Wilkinson Creek

Wilkinson Creek enters Torch Lake at its north end, about one mile southeast of Eastport Creek. The stream system has one unnamed tributary. It originates in swampy interdrumlin swales and flows about 3.75 miles through a mostly forested stream corridor before emptying into the lake. The stream is located in Central Lake and Banks Townships (Antrim County). It is shown on the Atwood and Central Lake 7.5 minute U.S.G.S topographic maps.

The greatest elevation of the creek's headwaters is 738 feet. The stream drops 147 feet in elevation, for an average stream gradient of about 39 feet per mile. There is no public land along the stream. The stream system is crossed by Scenic Highway (M-88), East Torch Lake Drive, and Bennett Hill and Church Roads.

At M-88, the stream is about twelve feet wide and six inches deep, with a gravelly bottom. Estimated streamflow is nine CFS. The stream water is slightly stained and slightly turbid. Thermal characteristics of the stream indicate that it has moderately-high ground water inputs. Wilkinson Creek is designated as a trout stream by the MDNR.

Wilkinson Creek was the site of kokanee salmon plantings in1965-66. The plantings were discontinued, and the salmon have not persisted.

In 1997, the MDNR surveyed 300 feet of the stream by electroshocking for the presence of Atlantic salmon. The stream was described as averaging four feet wide and one foot deep, with a depth range of 6 to 24 inches. The habitat composition was estimated to be 30% riffle, 20% pool, and 50% run. Streamside vegetation was white cedar and tag alder, and there was a good cover of brush and logs. The air temperature was 70° F. and the water temperature was 58° F. The survey found brook (to 7"), brown (up to 10" long), and rainbow or young steelhead (up to 2" long) trout; creek chub; and blacknose dace, but no Atlantic salmon. In all 66 fish totaling 4.59 pounds were captured.

Spencer Creek

Spencer Creek enters into Torch Lake on its southeast shore near the town of Alden. The stream system has one unnamed tributary. The stream is about 6.5 miles long. It originates in a large swamp and flows through a mostly forested landscape on its way to the lake. The stream is located in Helena Township (Antrim County). It is shown on the Alden, Leetsville, and Torch River 7.5 minute U.S.G.S topographic maps.

The greatest elevation of the creek's headwaters is 794 feet. It drops 204 feet in elevation, for an average stream gradient of about 32 feet per mile. There is no public land along the stream. The stream system is crossed by East Torch Lake Drive, Swamp Road, McPherson Road, and several residential streets in Alden.

At East Torch Lake Drive, the stream is about seven feet wide and eight inches deep, with a sand and gravel bottom. The stream water is slightly stained and slightly turbid. Thermal characteristics of the stream indicate that it has high levels of ground water input. Estimated streamflow is about seven CFS. Spencer Creek is designated as a trout stream by the MDNR, and is known to contain both brook and brown trout.

A "stream examination" was conducted by the MDNR in 1888. Brook trout and mottled sculpin were found above a dam near the stream's mouth. Below the dam, species more characteristic of the lake were found including northern pike, largemouth bass, minnows, and darters. Brook trout were planted in 1947 and 1950.

A study of Spencer Creek was conducted by Central Michigan University's Institute for Water Quality Research in 1985. Log perch, American brook lamprey, brown trout, and mottled sculpin were collected. The study concluded that the water quality of the stream is good, aquatic invertebrates were diverse and abundant, and that the stream provides good trout habitat.

The MDNR checked the stream for natural reproduction of Atlantic salmon in 1997 using a backpack electroshocker. No evidence of natural reproduction of Atlantic salmon was discovered, but brook and brown trout ranging from two to eight inches were present.

Rapid River

The Rapid River is a tributary to the Torch River. It is quite similar to the Cedar. The Rapid is 18 miles long and originates about six miles northeast of Kalkaska in a forested area of the Mancelona Plain. The Rapid River is located in Clearwater, Rapid River, and Cold Springs Townships in Kalkaska County. It is shown on the Leetsville, Torch River, and Westwood 7.5 minute U.S.G.S topographic maps.

For most of its length, it flows through a deep, picturesque valley which was probably carved by a larger glacial meltwater stream. The stream corridor is mostly forested, undeveloped cedar swamp.

The stream system has only five tributaries, a low number for a stream of this length. This indicates that tremendous quantities of cold, high-quality ground water discharge directly into the main stream channel. The total length of the five tributaries is about 12 miles, bringing the total channel length for the system to about 30 miles. Only one tributary, the Little Rapid River, is named. The Rapid is a second-order stream.

The stream system is crossed by roads nine times: Priest Rd.(nearest its headwaters), followed by Leetsville Rd., U.S. 131, Wood Rd. (twice), Underhill Rd., Kellogg Rd., Rapid City Rd. (C-597) and Aarwood Rd. (nearest its mouth).

The greatest elevation of the river's headwaters is 1,083 feet. The river drops almost 500 feet in elevation, for an average stream gradient of about 27 feet per mile. In a nine mile stretch between U.S. 131 and Kellogg Road, the river's gradient averages 36 feet per mile. As a result of the steep gradient, most parts of the stream have a gravel or rocky bottom. The last three miles have a low gradient with sand and organic sediments on the bottom. The lower 1.25 miles of the Rapid River is slightly impounded by the Elk Rapids Dam.

There is one dam on the river, creating a 30 acre impoundment called Rugg Pond. In the past this pond has been stocked with brook trout.

There is quite a bit of State land along the upper third of the river (upstream from Woods Road). In 1998, The State acquired a one mile stretch of stream (known as the Seven Bridges Property) with the assistance of the Grand Traverse Regional Land Conservancy. Clearwater Township's Freedom Park is located on the river just north of Rapid City.

Studies have shown that the Rapid River has high dissolved oxygen levels, due to the low temperature, turbulent flow, and low numbers of aquatic plants (which can reduce oxygen at night through respiration). A hydrologic study in 1993 determined that the Rapid River's average annual flow at Rapid City is about 104 CFS. Phosphorus levels were low, probably because of the forested condition of its watershed, coupled with the fact that ground water recharge rather than surface runoff supplies most of the river's water. The channel above Rapid City was never cleared for log drives and therefore contains an abundant supply of cover compared to most streams.

Electroshocking surveys of the Rapid and Little Rapid Rivers by the MDNR (most recently in 1996) have revealed a high population of wild brook trout in the Little Rapid and upper reaches of the Rapid, with brook, brown and rainbow trout all being found in the middle and lower reaches of the Rapid. The lower reach also contains white sucker, central mudminnow, sculpins, and creek chub. Anadromous rainbow trout (a.k.a. steelhead) ascend the Rapid from Torch and Elk Lakes in spring to spawn. The Rapid River is designated as a trout stream by the MDNR. It is considered a "premier" trout stream, although it is not listed as a blue ribbon stream.

Agriculture and Streams in the Upper Chain

The immediate watersheds of Ellsworth, Wilson, Benway, and Hanley Lakes have more agricultural activity than other parts of the watershed (40% vs 18% of the overall land use). Problems such as eroding stream banks; farming on steep, highly erodible slopes; poor manure management; over-fertilization; and livestock access to streams have been documented. In particular, numerous cultivation and livestock operations have been identified within 500 feet of Van Stratten, Ogletree, and Kitty Ann Creeks. The Natural Resource Conservation Service and the Antrim Conservation District in Bellaire addressed many of these problems during a 10-year project from 1988 to 1998. However, problems persist. A 1993 study suspected (but did not document) that pollutants in runoff from agricultural land are causing some water quality degradation in these lakes. A biological survey of Van Stratten Creek in 1992 in the vicinity of a livestock operation found severely impaired physical habitat conditions for fish as a result of sedimentation and nutrient enrichment.

Desmond Creek

Desmond Creek flows into the east end of Lake Skegemog. The stream system has one unnamed tributary. The stream originates about two miles upstream of its mouth in steep, wooded terrain. Most of its corridor is a cedar swamp. The Creek flows through the flat, swampy lowlands of the Skegemog Natural Area for about 3/4 mile before emptying into the lake. The stream is located in Clearwater Township (Kalkaska County). It is shown on the Torch River 7.5 minute U.S.G.S topographic map.

The greatest elevation of the creek's headwaters is 719 feet. The stream drops 130 feet in elevation, for an average stream gradient of about 65 feet per mile. The stream system is crossed by Rapid City Road, McNaulty Road, and a railroad grade along the boundary of the Skegemog Wildlife Area.

At Rapid City Road, the channel is about ten feet wide, one to two feet deep, swift, with a sand-gravel bottom. A type of algae called Vaucheria, typical of cold, calcium-enriched streams, grows in bright green, velvety mounds on the substrate. Thermal characteristics of the stream indicate that it has high levels of ground water input. Estimated streamflow is ten CFS. The stream's water is unstained and clear. Desmond Creek is designated as a trout stream by the MDNR.

Barker Creek

Barker Creek discharges to Lake Skegemog at its south end. The stream system has one unnamed tributary. The most distant headwaters of the stream are about 2.5 miles from its mouth. Barker Creek originates in wooded hills and fallow agricultural land. The last half mile flows through swampy terrain of the Skegemog Natural Area. The stream is located in Clearwater Township (Kalkaska County). It is shown on the Torch River 7.5 minute U.S.G.S topographic map.

The greatest elevation of the creek's headwaters is 758 feet. The stream drops 169 feet in elevation, for an average stream gradient of about 67 feet per mile. The stream system is crossed by M-72. At that point, the stream is about three feet wide and one foot deep, with a sand-gravel bottom. Thermal characteristics of the stream indicate that it has moderately-high ground water inputs. Estimated streamflow is about 4.5 CFS. The stream water is unstained and clear. Barker Creek is designated as a trout stream by the MDNR.

Battle Creek

Battle Creek delivers its flow into Elk Lake on the extreme south end. The stream system has three unnamed tributaries. The most distant of these tributaries originates about four miles upstream of the lake, in hilly forested uplands. Its corridor is mostly forested, and it flows through a large swamp system before discharging to Elk Lake through a marshy estuary. The stream is located in Whitewater Township (Grand Traverse County). It is shown on the Torch River 7.5 minute U.S.G.S topographic map.

The greatest elevation of the creek's headwaters is 748 feet. The stream drops 159 feet in elevation, for an average stream gradient of about 39 feet per mile. About half a mile of the stream flows through State land at its headwaters. The stream system is crossed by M-72, Lossie Road (a two-track), Watson Road, and Deal Road. At M-72, the stream is about 12 feet wide and one to two feet deep, with a sand bottom. Estimated streamflow is 25 CFS. Thermal characteristics of the stream indicate that it has high levels of ground water inputs. The water is unstained and slightly turbid. Vaucheria grows abundantly on the bottom. Battle Creek is designated as a trout stream by the MDNR.

Williamsburg Creek

Williamsburg Creek is a tributary to Elk Lake at its southwest shore. The stream system has one unnamed tributary. It flows through the town of Williamsburg, where an impoundment known as Bissel Pond is located. Above Bissel Pond it is known as Bissel Creek. The stream is about 5.5 miles long. It flows through a swampy, forested corridor. There are a series of private ponds in its lower reaches. The stream is located in Whitewater Township (Grand Traverse County). It is shown on the Williamsburg and Jack's Landing 7.5 minute U.S.G.S. topographic maps.

The greatest elevation of the creek's headwaters is 827 feet. The stream drops 238 feet in elevation for an average stream gradient of about 43 feet per mile. The stream flows through State land for about half a mile near its headwaters. The stream system is crossed by Ayers Road, Old M-72, M-72, and Williamsburg Road.

At Ayers Road, the stream is about 15 feet wide and one to three feet deep. The bottom is mostly sand, with some areas of gravel. Watercress, Vaucheria, and some rooted aquatic plants are evident. There are quite a few logs in the stream. The stream water is unstained and slightly turbid. Thermal characteristics of the stream indicate that it has moderately-high ground water inputs. Estimated streamflow is 20 CFS. Williamsburg Creek is designated as a trout stream by the MDNR.

—CHAPTER SIX—

Fisheries Management Concepts

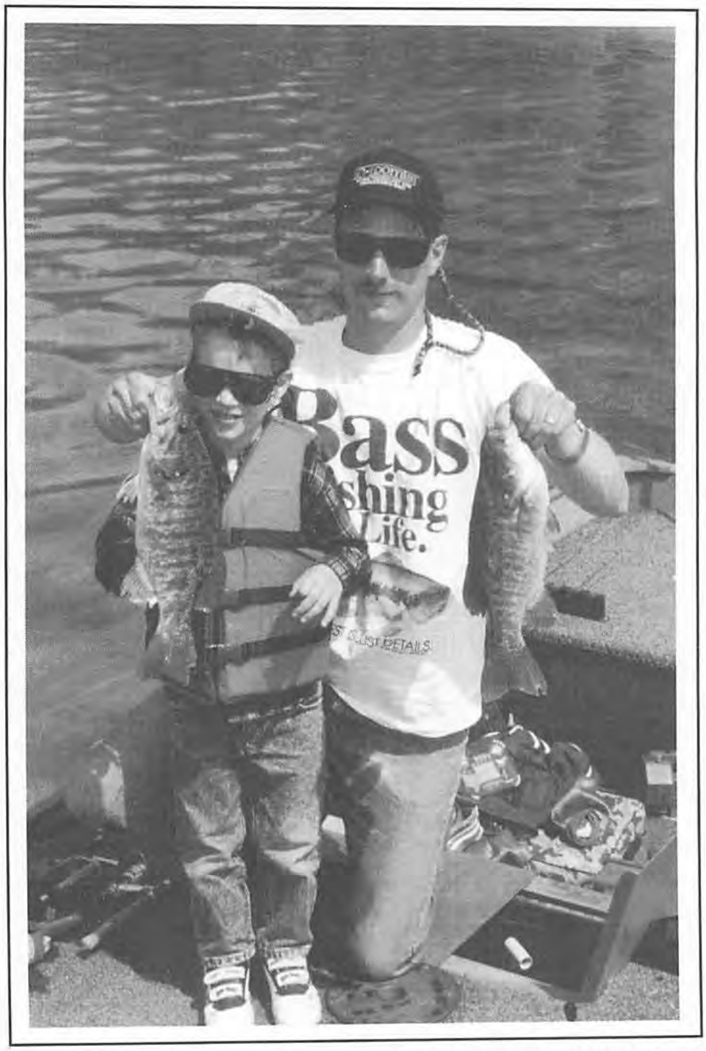


Photo courtesy of Paul Winkler

Although relaxation, enjoyment of nature, and good comradery are actually among the most important reasons people fish, getting lots of bites and catching big ones like these smallmouth bass by Paul Winkler and his son Bryan of Intermediate Lake is also an important goal for anglers. Maintaining healthy, stable, diverse, natural communities of fish in our lakes and streams is a basic fishery management concept, one which is primarily dependent on protecting water quality and ensuring suitable habitat. Paul and Bryan carefully released these fish after the picture was taken.

What is Fisheries Management?

You have probably heard the term "fishery" or "fisheries management" used in reference to activities taking place on a nearby lake or stream. A fishery has traditionally been defined as the harvesting of fish from water bodies for either commercial or recreational purposes. Of course, in the Elk River Chain of Lakes (ERCOL) Watershed there is little or no commercial fishing these days, so the fishery is a recreational one. Furthermore, traditional definitions are changing as fish become viewed as more than simply a harvestable commodity.

In most waters, fish are a public resource, the management of which is the responsibility of governmental agencies (either federal, state, or tribal—see sidebars). In Michigan, the Fisheries Division of the Michigan Department of Natural Resources (MDNR) is the primary fisheries management agency. Only the MDNR can set and enforce regulations and authorize management activities (including the planting of fish in lakes and ponds).

A Brief History of Fisheries Management

Fisheries management has changed a lot over the years. In the late 1800s, it seems like fish were only considered a resource to be exploited. Settlers and anglers caught and killed huge numbers of fish for sport and food (Figure 44). In the early days of fish management, fish populations were managed primarily to increase the size and number of game or food fish. Harvesting regulations and stocking were the major management techniques. However, some of these techniques were not based on sound knowledge. Fish were often stocked into waters without suitable habitat, or exotic species were introduced without regard for the consequences. Some early regulations were ineffective, or even counter-productive.

Interest in fish habitat protection and improvement developed in the 1930s. By the 1960s, research had led to more effective regulatory approaches. However, fisheries management still focused on individual species without much regard for population interactions or ecosystem dynamics. Not enough thought was given to protecting water quality or habitat, the negative impacts of stocking on other species (see sidebar), or maintaining the overall health of the native fish community.

Even though harvesting is still an important goal, fisheries management is increasingly part of a multi-faceted, ecosystem-based water resource management program. Fisheries managers now realize that healthy fish communities are primarily dependent on good water quality, suitable habitat, and other environmental requirements. Conversely, fisheries management activities can also affect the aquatic ecosystem. In some places, fish management activities are even being used to help improve water quality.

Fisheries Management in the Elk River Chain of Lakes Watershed by the Michigan Department of Natural Resources

The goals of the Fisheries Division of the MDNR are to:

- Protect and Maintain healthy aquatic environments and fish communities and rehabilitate those which are now degraded,
- Provide diverse public fishing opportunities to maximize the value to anglers of recreational fishing,
- Permit and encourage efficient and stable commercial fisheries that accommodate Indian fishing rights and do not conflict with recreational fisheries, and,
- Foster and contribute to public stewardship of Natural Resources through a scientific understanding of fish, fishing, and fishery management.

Fisheries management within the ERCOL is the responsibility of the Central Lake Michigan Management Unit (CLMMU) of the Fisheries Management Division of the Michigan Department of Natural Resources (MDNR). The CLMMU encompasses all the watersheds flowing into Lake Michigan from Muskegon north to the Straits of Mackinac. (Figure 45) As of Summer 2000, the unit supervisor is Mr. Thomas Rozich, Cadillac MDNR office, 8015 Mackinaw Trail, Cadillac, MI 49601 (231-775-9727). The local field fisheries biologists are Mr. Mark Tonello (also in the Cadillac Office), and Mr. Ralph Hay, Traverse City MDNR Office, 970 Emerson Rd., Traverse City, MI 49686 (231-922-5280). They are the people most knowledgeable about the fisheries resources in the ERCOL watershed, and are responsible for assessing the water resources and fisheries, and, based on those assessments, selecting and implementing fisheries management strategies.

Working closely with fisheries biologists to enforce fishing regulations are conservation officers. Conservation officers are part of the Law Enforcement Division of the MDNR. Persons wishing to report a fish or wildlife violation can call the Report All Poaching (or RAP) hotline, 1-800-292-7800. Other questions or concerns about fish and fisheries management should be directed to the CLMMU unit supervisor or local fisheries biologist.

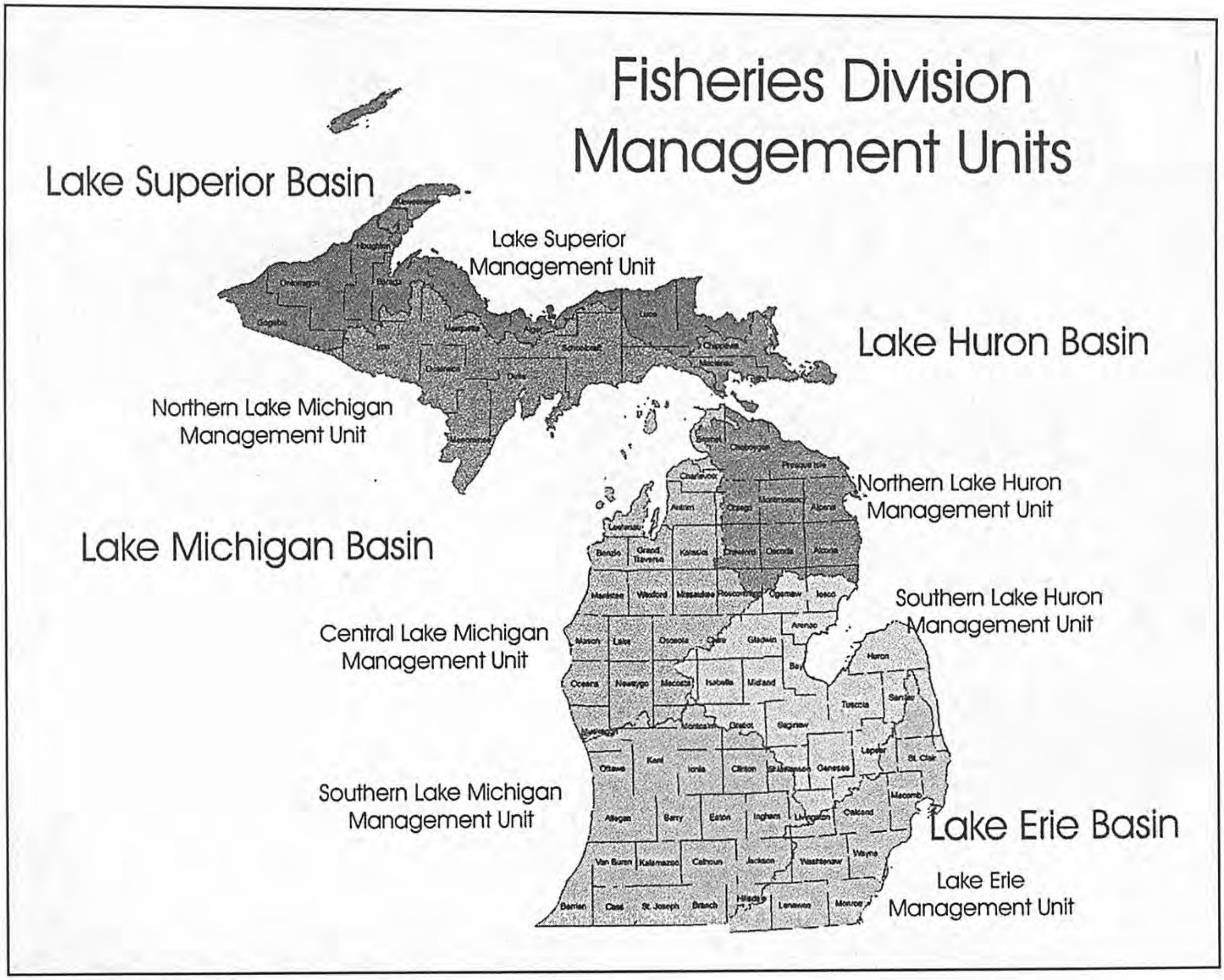


Figure 45 - Map of MDNR's Fisheries Division's Management Units.

Components of an Ecosystem-Based Fishery Management Program

There are six basic components of an ecosystem-based fisheries management program.

1. **Characterizing the water body and its fisheries.** This basic step is needed to understand the resources. It can also help identify problems (Step #4). The most basic waterbody characterization is gathering general physical, chemical, and biological information. If needed, gathering more specific information in selected areas can follow. Characterizing the fisheries includes identifying the species present and their basic life histories; as well as information about their size, abundance, and the level of harvest. Although a quite a bit of basic information has been collected on the waters of the Chain (and is summarized for each waterbody in Chapter Five), much still remains unknown.

2. **Characterizing lake users and their associated values.** To help ensure that fisheries management strategies are appropriate, it is important to know something about the anglers (are they residents or tourists?, riparians or non riparians?, etc.), their numbers, and their goals and objectives for the fishery. Additionally, fishing is only one of the many human uses of lakes and streams, and knowing more about other recreational activities (such as swimming, canoeing, or water skiing) may be important for avoiding user conflicts and maximizing the effectiveness of management actions.

3. **Choosing management goals and objectives.** Increasingly, maintaining healthy, stable, diverse, natural populations of fish are primary management goals and objectives. However, even in the era of ecosystem-based fishery management, most fisheries are still basically managed to produce more catchable fish, often of a certain species such as trout or walleye. In this regard, basic goals of most fisheries management programs by government agencies include the following:
   - Maximize number of fish caught,
   - Maximize catch rates per unit effort,

Natural Resources Management in the Elk River Chain of Lakes Watershed by the Grand Traverse Band of Ottawa and Chippewa Indians

Hunting and fishing rights were secured for Ottawa and Chippewa Indians in large areas of Michigan's northern lower and eastern upper peninsulas by the Treaty of Washington signed in 1836. This treaty established the 1836 Cession where inland rights exist (Figure 46). There are five Indian Tribes within the 1836 Cession, one of which is the Grand Traverse Band of Ottawa and Chippewa Indians.

The Inland Hunting and Fishing Program within the Grand Traverse Band's Natural Resources Department endeavors to develop and implement sound management strategies designed to preserve and enhance fish and wildlife populations and the resources which support them, ensuring the opportunity for current and future members of the Grand Traverse Band of Ottawa and Chippewa Indians to engage freely in activities that appreciate both the intrinsic and consumptive values of natural resources. The service area of the Grand Traverse Band is Antrim, Benzie, Charlevoix, Grand Traverse, Leelanau, and Manistee Counties, which includes nearly the entire Elk River Chain of Lakes Watershed. However, the Grand Traverse Band both offers and receives help in managing natural resources from the five other Bands throughout the 1836 Cession.

Broad management goals of the Grand Traverse Band for the multiple use of resources include:

- Developing a system of Tribal self-regulation of inland hunting, fishing, and gathering where the resources are preserved for use by future generations,
- Endorsing a Tribal co-management authority for fisheries and wildlife management in the 1836 Cession and expanding the current assessment program into this entity, and
- Establishing and maintaining technical working groups between Tribes and Federal and State agencies to regularly discuss inland assessment needs, review survey and assessment reports, make recommendations for future projects and assessments, and discuss and make recommendations for future management strategies.

Immediate management objectives include:

- Solidifying a Uniform Conservation code for all five 1836 Treaty Tribes,
- Identifying inland fish and game resources available in the prescribed management areas of the 1836 Cession,
- Identifying and declaring anticipated Tribal use or harvest of inland fish and wildlife resources in the 1836 Cession, and,
- Implementing management strategies to protect resources from over-harvest.

Figure 46 - Map showing the 1836 Cession.

- Maximize bites per hour,
- Maximize the number and size of trophy fish,
- Provide fishing opportunities for a particular species,
- Provide fishing opportunities for wild fish,
- Maximize the diversity of fishing opportunities,
- Provide a relatively pristine, undisturbed natural environment for fishing,
- Maximize the ease and convenience of fishing,
- Provide edible fish with little or no health risk,
- Ensure long-term sustainability of the fishery,
- Conserve fish through catch and release fishing,
- Protect populations of threatened or endangered species, and,
- Protect and manage water quality through fish management.

It is important to note that some of these goals can be incompatible with each other, such as providing an undisturbed environment and maximizing the ease and convenience of fishing.

4. **Identifying major problems, causes, and limiting factors.**
Most fisheries problems are associated with low or declining fish abundance, catch per unit effort, or yield. Figure 47, modified from *Fish and Fisheries Management in Lakes and Reservoirs*, a 1993 publication prepared by the U.S. EPA and the Terrene Institute (a nonprofit corporation focusing on environmental research and education topics), shows common fisheries problems and their causes.

COMMON CAUSES	COMMON FISHERIES PROBLEMS								
	Low Yield	Low Abundance	Too Few Older Fish	Too Few Young Fish	Fishkills	Slow Growth	Reduced Fecundity	Reduced Biodiversity	Tumors
Habitat Degradation	X	X	X	XX	X	X		X	
Inadequate Spawning Habitat	X	X	X	XX					
Water Level Fluctuations	X	X	X	XX	X	X			
Low Oxygen	X	X			XX			X	
High Temperature	X	X			XX				
Excessive Sediments/Turbidity	X	X		X		X			
Dams/Diversions/etc.	X	X	X	X					
Acidity	X	X		X	X	X	X	X	
Toxic Substances	X	X	X	X	X	X	X	X	X
Excessive Plant Growth	XX				X	XX			
Low Water Fertility	XX	X				XX			
Excessive Water Fertility					X			X	
Low Prey Availability	X	X				XX			
Undesirable Fish Species	X	X				X			
Over-Fishing		X	XX						
Under-Use	XX								

XX indicates strongest and most reliable problem-cause relationship.

Figure 47 - Common fisheries problems and their causes.

Hatcheries and Stocking

The practice of raising fish for sport fishing began about 1850. Stocking used to be considered a widespread solution to poor fishing. It is now considered useful in a much more limited way, usually only where adequate spawning habitat or other key habitat features are lacking. Trout are the most commonly raised species, because they are easy to raise and are a highly prized sport species.

Hatcheries and stocking have many disadvantages. Hatchery fish are considered weaker than naturally-reproduced fish. Fish released into lakes and streams from hatcheries are usually genetically different than the species naturally present. When they breed with native fish, they can weaken the gene pool. Hatchery fish are often more aggressive than native fish. Native fish can be driven out of their territories, but then many of the planted fish die off, leaving fewer fish than originally. Introductions of non-native species can have adverse impacts on native species and affect other lake uses as well. Many species are very difficult to raise. Stocking can be very expensive. Hatcheries can cause pollution problems and are sources of disease.

While still playing an important role in fish management under certain conditions, stocking is no longer considered appropriate for every lake or stream or regarded as a solution every time poor fishing is reported.

Photo courtesy of *Views of the Past.*

Figure 44 - Six men with a catch of over 100 smallmouth bass—almost four times the limit allowed today.

5. **Selecting and implementing management approaches.**
   What can be done to correct problems once they are identified? Figure 48, also modified from *Fish and Fisheries Management in Lakes and Reservoirs*, identifies the management actions most appropriate for addressing each type of problem.

6. **Monitoring the results.**
   Monitoring is a necessary component of any management action to determine its effectiveness and identify any new problems which may arise.

What Can Individuals do to Help Protect and Manage Fish Resources?

Proper fisheries management includes instilling a sense of responsibility in those who fish and harvest fish. If every angler keeps five bass per outing, that could add up to thousands of bass per lake—perhaps more than the fishery could sustain in some cases. Although there is nothing wrong with keeping a reasonable amount of fish, it is better to "limit our take rather than take our limit."

We all live in a watershed, and many everyday actions inadvertently cause pollution or impairment of water resources. Voluntarily adopting a lifestyle that minimizes or prevents habitat destruction and nonpoint source pollution can ultimately help protect fisheries (see Chapter One for a list of types of nonpoint source pollution).

Although it would be great if everyone voluntarily did the right thing, state and federal laws and local ordinances will always be needed to ensure adequate resource protection. Individuals can help by complying with existing regulations and by supporting new laws which are needed to protect water resources.

Fisheries management activities can be expensive, and, unfortunately, funding is a major limiting factor. A majority of the funding for their activities comes from user's fees such as license revenue and taxes on equipment. Supporting adequate funding of resource management agencies will help protect and properly manage the fisheries resources of the ERCOL Watershed.

MANAGEMENT ACTIONS	CAUSES OF PROBLEMS IN FISH POPULATIONS															
	Habitat Degradation	Inadequate Spawning Habitat	Water Level Fluctuations	Low Oxygen	High Temperature	Excessive Sediments/Turbidity	Dams/Diversions/etc	Acidity	Toxic Substances	Excessive Plant Growth	Low Water Fertility	Excessive Water Fertility	Low Prey Availability	Undesirable Fish Species	Over-Fishing	Under-Use
Habitat Protection	X	X	X		X	X	X							X		
Reduce or Eliminate Toxics	X								X							
Reduce Nutrient Loads	X			X	X					X		X				
Lake Fertilization											X					
Aerate/Increase D.O.	X			X								X				
Liming	X							X								
Spawning Habitat Improvements	X	X														
Aquatic Plant Management	X	X								X						
Water Level Management	X		X							X						
Voluntary Stewardship	X								X			X			X	
Fish Cover Structures	X															X
Game Fish Stocking	X	X			X											
Undesirable Species Control	X					X								X		
Prey Enhancement													X			
Fishing Regulations and Enforcement															X	

Figure 48 - Fisheries management actions.

Fish Population and Community Assessment Methods

1. **Gill nets.** Gill nets are one of the most common types of fishing gear. They consist of a mesh net suspended vertically in the water by floats on top and weights on the bottom. Fish swim into the net, poke their heads through the mesh openings, and are unable to back out because their gill covers become entangled (Figures 49 and 50). The big disadvantage of gill nets is that unless tended frequently, they can kill fish.

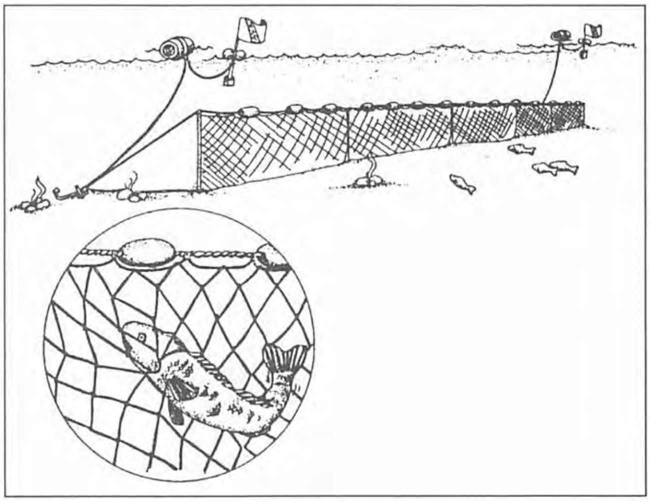


Figure 49 - Gill Net. (Figure from *Fisheries Techniques*, published by the American Fisheries Society)

Figure 50 - Retrieval of a gill net brings a yellow perch to the surface. (Photo courtesy of Jim Gapczynski)

2. **Traps.** Hoop, trap, and fyke nets are all types of fish traps which consist of large cylindrical or rectangular net structures supported by framing, rods, floats, or anchors that funnel fish in and lead them down to a capture chamber at the far end (Figure 51). Small wire or glass traps are familiar to many anglers, who use them to catch minnows for bait (Figure 52).

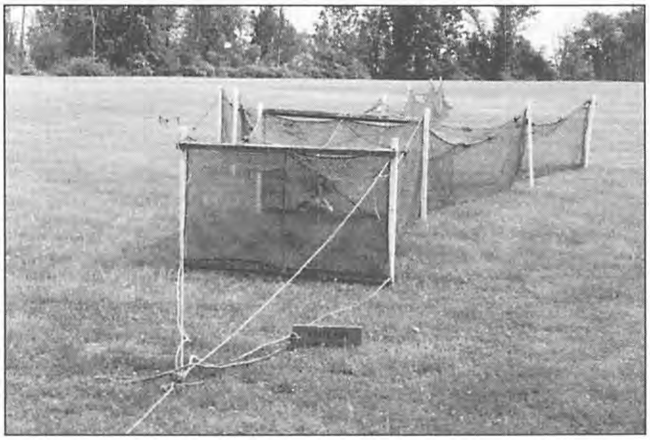


Figure 51 - A trap net set up on a lawn for display. (Photo courtesy of Jim Gapczynski)

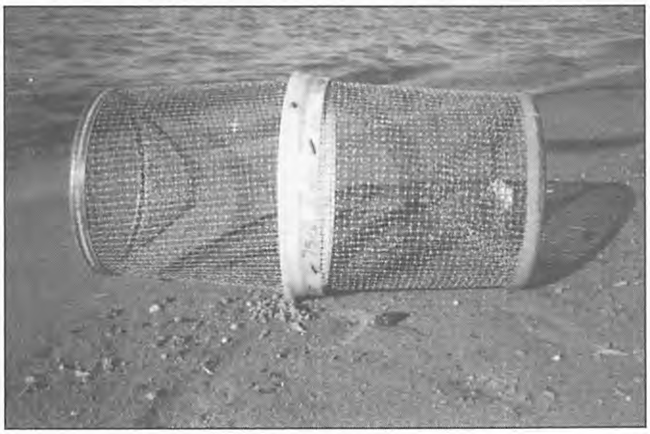


Figure 52 - Wire minnow trap.

Figure 53 - A seine net dragged through the nearshore shallows is an excellent method for capturing small, slow-swimming fish.

Figure 54 - A sand shiner, johnny darter, and juvenile yellow perch captured by a seine.

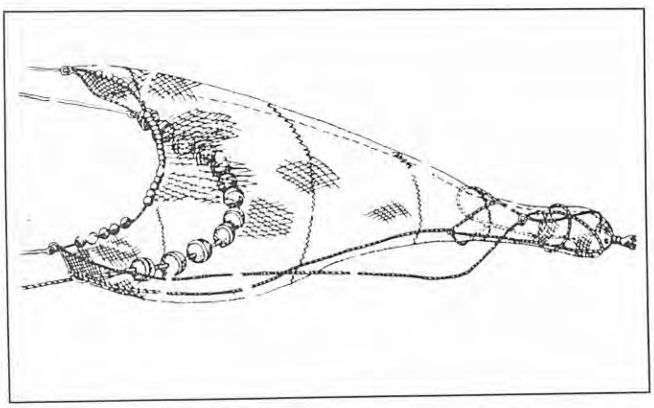


Figure 55 - Trawl net. (Figure from *Fisheries Techniques*, published by the American Fisheries Society).

3. **Seines.** A seine is a long mesh panel with a baggy middle portion that is generally dragged through the water by two people. Seines are usually limited to shallow, nearshore waters (Figures 53 and 54).

4. **Trawls.** A trawl is a net bag towed through the water behind a boat (Figure 55).

5. **Angling.** Angling is usually a recreational activity, but it can be an effective way to collect some species or a few individual fish.

6. **Electrofishing.** This involves the use of electricity to shock and stun fish, which then float to the surface where they can be scooped up by dip nets. Most stunned fish are revived and returned to the water unharmed, but a small percentage die. Electroshockers come in either boat- or backpack-mounted units (See Figure 43, Chapter Five).

7. **Fish Toxicants.** There are a number of toxic compounds which can be used to kill fish but which otherwise have limited water quality impacts. In confined areas or carefully controlled applications, the toxins will kill all of the fish present, providing a complete sample of the population. They are also sometimes used in an attempt to eliminate exotic or problem species when they are concentrated in a small area. One of the most commonly used is rotenone, a natural plant derivative.

8. **Hydroacoustics (electronic devices emitting sound waves).** One example is the common fish finder sold in tackle shops. More sophisticated devices are available which can accurately identify species and even estimate numbers and weights of fish.

9. **Visual observations.** This includes direct observation using SCUBA, snorkeling, remote underwater cameras, or devices to enhance underwater viewing from above.

10. **Modeling.** A model is a simplified representation of a real object, process, concept, or system. Model boats and planes are probably the most common examples in daily life. A model can also be a set of mathematical equations that simplify the processes occurring in lakes and streams into quantitative, understandable terms. Increasingly, models are being developed to understand and manage all types of natural resources, including the amount of fish a particular lake or stream is capable of producing and yielding on a sustainable basis

11. **Catch Statistics.** Creel surveys, angler diaries, and questionnaires are all methods to help answer questions about the number, kind, and size of fish being caught and other aspects of the fishing experience. A detailed creel survey, which might include airplane estimates of the number of fishing boats coupled with interviewing anglers on a known percentage of those boats, can accurately estimate the number of fish harvested from a lake in a season. However, catch statistics cannot provide valid information about fish community structure or indications of potential change. An example of a recent creel survey for Elk Lake is provided in Chapter Five.

Understanding Population Dynamics in a Lake or Stream

While looking out over a lake or stream, you may have wondered how many fish live there, how many of each species, how many of a certain sport species are of legal size, or how big are the largest ones. If the water could be magically, instantaneously, drained away and you could walk around on the bottom throwing the flopping fish into a basket, the total amount of fish you would find is called either the population (in ecological terms), or the standing stock (in fish management jargon).

Standing stock is usually expressed either as numbers of individuals or as the weight of fish in pounds per surface acre. It is usually somewhat less than the maximum the lake or stream is capable of supporting (called carrying capacity) because there is usually some harvesting by people, or other mortality.

Standing stock is highly variable, but in stable environments it tends toward some long-term average that is a reflection of carrying capacity. The factors affecting standing stock (food, water temperature, water quality, reproductive success, habitat, competition, fish health, and mortality) are difficult to observe or measure and have not been documented for the Chain of Lakes. However, studies of lakes and streams similar to those of the Chain have reported standing stocks of 50-200 pounds of fish per acre, with about 90 pounds per acre seemingly an average figure. Some very productive lakes in other parts of the Northern U.S. have standing stocks of up to 600 pounds per acre.

The standing stock is composed of all the various species in the lake or stream, each with their own average and maximum amounts (Figure 56). When there are many different species in a waterbody, the carrying capacity and standing stock are usually greater than when there are only a few species because there is more complete utilization of the available food.

Species	Mean	Maximum
Trout	4	40
Walleye	7	35
Rock Bass	8	30
Northern Pike	8	25
Yellow Perch	9	22
Largemouth Bass	16	60
Sucker	30	200
Bluegill	40	200
Bullhead	50	350

Figure 56 - Mean and maximum standing stock (pounds per acre) of common species in the Chain of Lakes (from studies in other watersheds).

While picking up fish, you could also sort them according to species. In general, large numbers of an individual fish species usually indicate small individual sizes and vice versa. For instance, a lake may have thousands of minnows per acre, but only a couple adult muskellunge (because they require a lot of food, and they have large territories). Species which are relatively the most abundant are probably those which are best adapted to the water quality or habitat conditions present in that lake or stream.

If you were to further separate all the fish of a given species into different size categories, each category would represent a different age group. Because fish are constantly being removed from the population by fishing and other mortality, the number of fish in each age group decreases year by year, with many young ones and only a few big, old ones. The size of each age group, especially when compared to the size of fish of similar age from other waters, provides insight into whether they are growing relatively fast or slow, which in turn is probably a reflection of food availability.

Fish are always dying and being replaced by new or younger fish. The orderly entry of juvenile fish into the population is called recruitment. The amount of fish flesh gained over a specified period (most commonly one year) by both new recruits and older fish is termed fish production. The amount of production can be estimated by determining the average amount of weight gained by each year class taking mortality into account. Because of the inefficient energy transfer along the food web, fish species which are lowest on the food pyramid (see Chapter Two) generally have the highest production potential.

Of course, draining away the water in the Chain of Lakes is not a possibility. However, by collecting a sample of the fish population using one of the methods discussed in the previous sidebar, marking them, and determining what percent of marked fish are recaptured using an identical technique, accurate estimates can be made of standing stock, species composition, growth rate, and production.

Another important characteristic of the fish population is the amount harvested by people. This is termed yield and is usually reported in pounds per acre per year. An important concept in fisheries management is sustainable yield. Sustainable yield is that which can occur indefinitely without causing any long-term decline in standing stock. Different studies have shown that sustainable yield is 20% to 50% of the standing stock. Sustainable yield is dependent on the population's annual net production—waters with high production can yield more fish than waters with low production.

Catch and Release Fishing

Why Release Fish?

There is a limit to the number of fish available to anglers, and fish are coming under increasing pressure and declining in numbers in many places. To conserve sport fish, regulations such as bag limits, size limits, closed seasons, and in some cases the total protection of a species have been established. As a result, anglers often catch fish that the law requires them to return to the water. In addition, the benefits of voluntarily releasing some fish that could legally be kept are widely recognized. Released fish can live on to be caught later when they are bigger. They also continue to spawn, helping to improve populations.

All anglers are encouraged to practice catch and release whenever possible. Catch and release fishing is gaining in popularity as more anglers are becoming aware of its benefits. Young anglers in particular can be introduced to the concept at an early stage, and often become enthusiastic proponents. However, simply letting the fish go after capture is not all there is to catch and release fishing.

If a fish is released in such poor condition that is likely to die, the whole point of releasing fish is defeated. Even fish that appear to be unharmed when released may not survive if they have not been carefully handled. Numerous studies have shown that when fish are released with great care and skill, up to 75 percent will survive. Many anglers have developed advanced skills that enable them to successfully catch fish. Similarly, they can also acquire the following skills needed to help ensure that released fish will live to be caught again.

Tips for Catch and Release Fishing

1. **Avoid catching non-target species.** It is best to try to catch only the fish you are after in the first place. You can sometimes avoid hooking undersized fish by moving to different fishing spots or by increasing the hook size. Changing rigs, baits, or location may also allow you to target different species once your bag limit for one type has been reached.

2. **Prevent the fish from swallowing the hook.** Fish hooked in the gills and gut are less likely to survive than those hooked in the mouth. The use of lures or flies is more likely to result in lip-, jaw-, or mouth-hooked fish. When using bait, stay alert for bites so fish don't have a chance to swallow the hook.

3. **Do not remove swallowed hooks.** If you want to release a fish hooked in the gills or gut, cut the line as close to the hook as possible and leave the hook in place. Digestive fluids in the gut or even gill area will eventually dissolve hooks with far fewer ill effects than physical removal. Avoid the use of stainless steel hooks, because they do not dissolve as well as regular steel.

4. **Carefully remove the hook from lip or mouth-hooked fish.** Do not roughly twist or tear out hooks, but pull them out opposite the angle of entry using a gentle yet quick motion. Special hook disgorgers, long-nosed pliers, or hemostats can aid hook extraction. The use of barbless, single hooks makes unhooking easier. Barbless hooks can be purchased, or barbed hooks can be made barbless by crushing the barb flat with pliers.

5. **Catch and release fish quickly.** A fish fighting on the end of the line experiences an increase in the production of stress-related hormones; a build-up of lactic acid; and a change in the concentrations of hemoglobin, glucose, and salts. If these stresses are great enough, they can result in death, either immediately or later on. Stress can be reduced by catching and releasing fish quickly and minimizing the time they are out of water. Avoid releasing the fish into warm, shallow margins of lakes and streams if deeper, cooler water is accessible. Some fish, especially after a long struggle, may lose equilibrium and float belly-up. To revive, hold the fish upright in the water and move it forward and backward so that water runs through the gills until it revives, begins to struggle, and can swim normally.

6. **Handle fish gently.** Never suspend large fish by the line or with a finger in the gills because this can place enormous strain on sensitive body parts. In fact, removing large fish from the water should be avoided if release is intended. Instead, keep the fish in the water as much as possible and remove the hook from that position. If a small to medium sized fish must be landed and there is no danger of human injury from sharp spines or teeth, it may be best lifted using the "comfort lift." Place a wet hand under and across the flat part of the body and lift the fish out of the water on its side. Using this technique often results in the fish remaining motionless for a long time. Do not squeeze the fish. Fish without teeth (such as bass) can be lifted by gripping the lower jaw, but only if held vertically (see Chapter Six's introductory photo). Holding a fish horizontally by its jaw (as is often seen in trophy pictures) may damage the mouth and neck. Nets can be beneficial, provided the mesh does not become entangled in the gills, and the net is made of knot-less mesh that will minimize skin and eye damage. When putting a fish on a surface to measure it or remove a hook, use a smooth, wet surface. Covering the fish's eyes can help settle it down. Never lay the fish on the beach or on the ground, or allow it to thrash against hard objects.

Back cover—
Aerial Photo of Torch and Elk Lakes in the Lower Chain of Lakes

This remarkable photo shows the long deep basins scoured by the glacier in ancient valleys in the shale bedrock and now occupied by Torch and Elk Lakes, the two largest lakes in the Chain (foreground). East and West Grand Traverse Bays, the Leelanau Peninsula, and North and South Manitou Islands in Lake Michigan are visible in the background.

The clear waters of Torch Lake reveal dune-like formations of sand in the nearshore shallows ending in sharp drop-offs. A plume of darkly stained water from Spencer Creek hugs the shoreline south of Alden. Other features visible include the head of the Torch River, the mouth of the Rapid River, and the Village of Elk Rapids, where the waters of the Chain of Lakes empty into Lake Michigan. Photo courtesy of Ted Cline, M.D., of Photair, Inc., Traverse City (231) 946-5570.

Tip of the Mitt Watershed Council—Over Twenty Years of Water Resource Protection

The Tip of the Mitt Watershed Council is the voice for Northern Michigan's waters. We are dedicated to protecting our lakes, streams, wetlands, and ground water through respected advocacy, innovative education, technically sound water quality programs, and through research. We achieve our mission by empowering others and we believe in the capacity to make a positive difference. We work locally, regionally and throughout the Great Lakes Basin to achieve our goals.

The Tip of the Mitt Watershed Council was formed in 1979 by local lake associations with assistance from the University of Michigan Biological Station. Ten full-time staff members work to prevent the degradation of Northern Michigan's crucial waters. The Watershed Council is a nonprofit organization supported primarily through private donations.

Please contact us for more information—

Address: 426 Bay Street, Petoskey, MI 49770
Phone: 231-347-1181
Fax: 231-347-5928
Email: info@watershedcouncil.org
Website: www.watershedcouncil.org