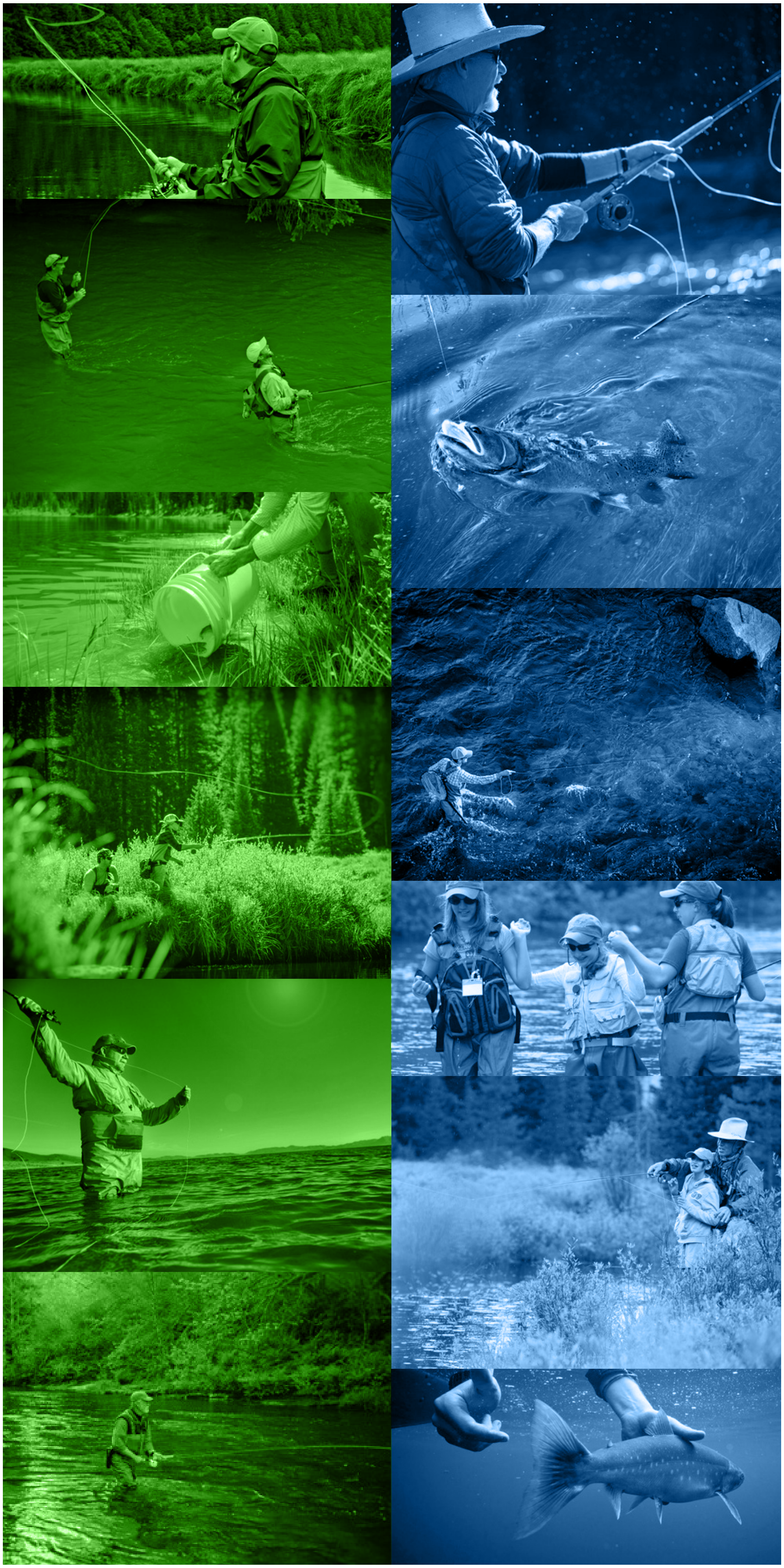

A CASE FOR THE GREAT LAKES

Produced by the Trout Unlimited NLC Great Lakes Workgroup

A CASE FOR THE GREAT LAKES

TROUT UNLIMITED

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TROUT UNLIMITED

VISION STATEMENT

21% of the world's freshwater is contained within the boundaries of the Great Lakes. In keeping with Trout Unlimited's Mission Statement to conserve, protect and restore cold-water fisheries, the Great Lakes NLC Workgroup would like to ensure paramount recognition and attention is given to the single largest source of cold-water in the United States.

Four hundred years ago, the Great Lakes Region, inhabited by Native Americans, were a pristine collection of freshwater oceans as first seen by the early French explorers who looking for riches and a route to the Asian trade markets. At that time, the Great Lakes were protected from outside aquatic invaders and upstream human travel by a 600' elevation change along their outlets to one another and the Atlantic Ocean via Niagara Falls and the St. Lawrence River.

Enormous changes came to the Great Lakes in the early 19th century with the development of locks and canals to improve the movement of trade goods and individuals between the lakes and the eastern coastal states and major cities. By the 20th century, the protections once afforded by gravity and flow were breached and aquatic invaders stormed into the Great Lakes. The coup de grâce to the stability of the Great Lakes was the completion of the St. Lawrence Seaway with the hopes of creating a trading mecca by opening access to the cities bordering the lakes. The ballast waters of the ocean ships, "salties" as they are known, have brought hundreds of invasive species into the lakes. Sadly, invasive species are only the beginning of the issues threatening the Great Lakes.

What follows is a collection of essays that describe the physical make up of the Great Lakes, the population and users in the surrounding states, and the salmonid fisheries in the lakes, and provide an overview of the many threats to the lakes today and a summary of challenges and choices facing the world's largest, by area, coldwater resource.

Proposed Uses of the Document:

1. Engage the TU Community by providing them reference material relevant to the history, physical characteristics, and significant coldwater fisheries of the Great Lakes region, and outline the multitude of threats it faces.
2. Provide a document that builds a case for why and how Trout Unlimited should be more involved with the issues of the Great Lakes Region.
3. Provide a document that can be given to decision makers, liked-minded partners, and potential funders.

VISION STATEMENT (cont.)

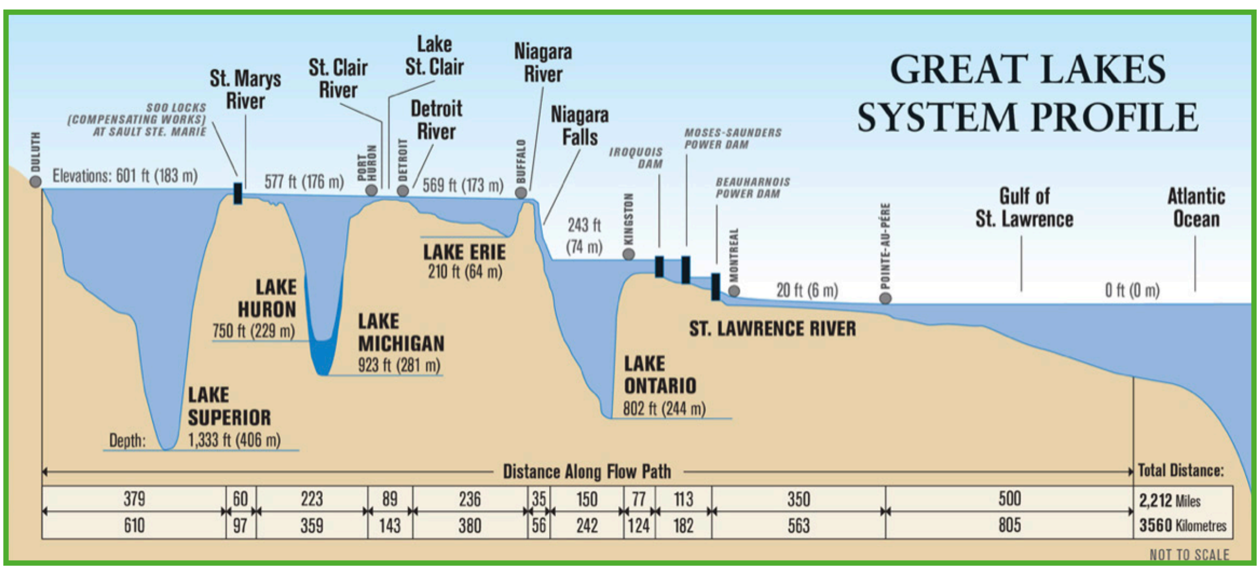
Outlook: As viewed from almost any access, the Great Lakes look beautifully clear and tranquil, but in reality, they are in a state of flux and are being attacked from all sides, over and under the surface of the waters. The illustrations presented in this document make that abundantly clear and show there is much to be concerned about. But there is also good news. As the threats to the Great Lakes continue to grow on a seemingly daily basis, so too, literally hundreds of new innovative solutions are brought to us through science, research, and the good works of private and governmental organizations. The greatest challenge to the future health of the Great Lakes will be identifying and empowering stakeholders and decision makers to develop and implement new solutions in service of the ecological restoration of the Great Lakes.

Great Lakes Watersheds

Courtesy of Robert Szucs/www.grasshoppergeography.com

GREAT LAKES BY THE NUMBERS

- **84%** of North America's surface fresh water
- About **21%** of the world's supply of surface fresh water
- Combined shoreline of **10,210 miles**; that's nearly half the circumference of the globe at the Equator
- Population is more than **50 million** people - roughly **10%** of the U.S. population and more than 30% of the Canadian population
- Accounts for nearly **25%** of Canadian agricultural production and **7%** of American farm production
- The region's GDP is USD **$5.8 trillion**, or roughly **28%** of combined U.S. and Canadian economic activity
- If the Great Lakes Region were a standalone country, it would rank 3rd only behind the United States and China in terms of GDP (followed by Japan, Germany and the UK)
- The Great Lakes commercial, recreational, and tribal fisheries are collectively valued at more than **$7 billion** annually and support more than **75,000 jobs**
- The Great Lakes support **139 native species**, including lake trout, walleye, large and smallmouth bass, and brook trout
- **61 fish species** in the Great Lakes are considered to be threatened or endangered
- **18 fish species** are extinct or extirpated from at least one Great Lake



Great Lakes System Profile graphic, Michigan Sea Grant, The Great Lakes Basin, map/poster.

TROUT UNLIMITED

GREAT LAKES BY THE NUMBERS (cont.)

TU in the Great Lakes

- Membership: **43,921 volunteer members** (**30%** of TU membership)
  MI - 6,802
  WI - 4,782
  MN - 3,233
  IA - 1,000
  IL - 2,968
  IN - 1,052
  OH - 3,024
  PA - 13,742
  NY - 7,318
- Staff: **12 full time staff**, not including seasonal hires

**TOP TEN STATES
RANKED BY ANGLER EXPENDITURES**

Rank	State	Total Exenditures	Number of Anglers
1	FL	$4,953,493,028	3,091,952
2	NY	$2,696,493,564	1,882,280
3	MI	$2,465,535,795	1,744,206
4	MN	$2,440,230,389	1,561,881
5	CA	$2,393,961,476	1,673,633
6	TX	$2,014,497,308	2,246,367
7	OH	$1,903,619,503	1,341,657
8	NC	$1,655,538,064	1,524,578
9	WI	$1,459,883,024	1,246,775
10	VI	$1,407,011,422	832,641

**TOP TEN STATES:
NON-RESIDENT FISHING DESTINATIONS
RANKED BY NUMBER OF VISITING ANGLERS**

Rank	State	Non-Resident Anglers	Non-Resident Expenditures
1	FL	1,197,279	$898,283,876
2	MI	347,029	$326,337,857
3	WI	336,753	$445,006,874
4	NC	328,810	$260,296,738
5	AL	327,418	$361,768,322
6	NY	297,070	$282,573,249
7	OR	264,424	$241,771,577
8	MN	259,324	$364,108,877
9	NJ	256,950	$106,323,764
10	MS	244,390	$305,686,074

Table 1: American Sportfishing Association 2014 Report https://asafishing.org/uploads/Sportfishing_in_America_January_2013.pdf

TROUT UNLIMITED

THE GREAT LAKES AS A FISHERY

Starting in the late nineteenth century, anthropogenic factors led to the collapse of the historically abundant and diverse native salmonid populations in the Great Lakes (Atlantic salmon, lake trout, coaster brook trout, and various corrinoids). Commercial fishing overexploited native lake trout stocks especially in Lakes Michigan and Huron. Numerous non-native species also made their way into the system beginning in the late 1800s, some unintentionally introduced (sea lamprey, alewife, dreissenid mussels, round goby, etc.), others intentionally introduced (Chinook and Coho salmon, rainbow trout, brown trout, etc.). Since the mid-1950's, these non-natives have driven both the dynamics and management of the Great Lakes' fisheries.

Lake trout stocks were suppressed to low levels through overexploitation of commercial fishing, and the introduction of sea lamprey into the Great Lakes added an additional stressor on these fish, which ultimately led to the loss of native stocks of lake trout from most of the Great Lakes except for Lake Superior. The modern effort to rehabilitate the lake trout throughout the Basin began in the 1950s with the support of the US Fish and Wildlife Service and has produced some successes, most notably in Lake Superior, the only Great Lake in which native stocks of lake trout were not extirpated. Elsewhere, lake trout restoration played out against the epic proliferation of exotic alewife and the concomitant rise of an open water sport fishing industry built around massive state agency production and stocking of Pacific salmonids adapted to consuming the abundant alewife (primarily Chinook, Coho salmon and steelhead). These coldwater fish were introduced into the Great Lakes purposefully, as a means of both biologically controlling unchecked alewife populations, while simultaneously creating an incredibly valuable recreational fishery where none had existed. The result of these introduced coldwater fish was transformative in creating thriving local economies supported by recreational fishing and tourism, and ultimately led to lakeshore communities dominated by industrial waterfronts being converted to tourism meccas.

Alewife numbers subsequently decreased across the Basin, initially due to the predation by excessive numbers of stocked Pacific salmon and trout, resulting in a decades long era of relative stability and economic prosperity from the salmon, steelhead and trout fisheries. Later, new non-native species introduced into the Great Lakes through shipping ballast water lead to fundamental food web disruption yet again. Zebra mussels provided the first front, followed in time by a close relative, the quagga mussel. These small mussels have effectively blanketed the bottom of the Great Lakes, en masse, effectively filtering out much of the pelagic plankton base of the food web. This resulted in population crashes of alewife and has had significant negative effect on pelagic fish species like salmon, but also native species such as whitefish.

THE GREAT LAKES AS A FISHERY (cont.)

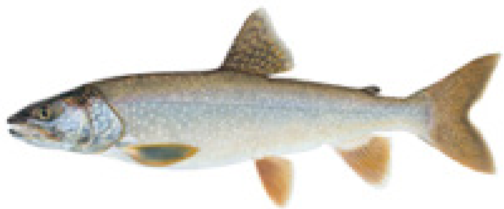
Atlantic salmon were native to one of the Great Lakes and have been introduced in other parts of the Great Lakes where they were not. In New York there is a hatchery-augmented Atlantic salmon stocking effort yet there is some natural reproduction present as well, with wild adult returns of Atlantics to some New York streams. In Michigan, introduced and hatchery-augmented Atlantics from land-locked Maine strain fish have proven to be more diverse foragers, and have performed well and created exciting fisheries where Pacific salmon have struggled. There, the hatchery-based effort is slowly expanding with the goal of filling the void left by pacific salmon lost in Lake Huron after zebra and quagga mussels collapsed the alewife population. Establishment of self-sustaining populations of Atlantics will necessitate expansion or reallocation of suitable stream habitat to Atlantics and require fully protective regulations in the open water and stream fisheries.

The Great Lakes have undergone several fundamental ecological shifts due to both unintentional and intentionally introduced aquatic species. Trout Unlimited's mission encompasses all coldwater fish and seeks to create high quality coldwaters that can support both wild and native fisheries. From its earliest times, it has worked to focus on habitat enhancement to foster self-sustaining populations, focusing first on brown trout and brook trout in places where they were not native. Within the Great Lakes, there are diverse values held for both wild introduced species and native species. There is associated work for both lake trout restoration as well as maintaining pacific salmon and steelhead fisheries, which are increasingly comprised of mostly wild fish. Lower abundances of baitfish species still persist due to the effect of zebra and quagga mussels, and this has posed conflicts as to the relative stocking rates of lake trout and pacific salmonids. Both rely on some level of hatchery augmentation to maintain the populations at levels high enough to meet management goals for each. Both kinds of fisheries are valuable, and both are limited by fundamental ecological limitations posed by nuisance species, which have altered what the Great Lakes are, continuing to threaten the future potential of these lakes. Ballast water as a pathway for more invasive species has not been adequately addressed, and the threat of species like Asian Carp through other pathways to the Great Lakes looms over the future of diverse healthy self-sustaining coldwater fisheries.

SALMONID FISH SPECIES

NATIVE SPECIES

Lake Trout



Lake Trout are a native species and found in all five of the Great Lakes as well as deep, cold regions of inland lakes. Though commonly called trout, Lake Trout along with the Brook Trout are actually in the char family. An average lake trout weighs 9 to 10 pounds but can become much larger with record weights exceeding 50 lbs. Lake Trout are fall spawning, preferring shoals, reefs and cobble bottoms. Lake Trout feed primarily on other fish, including ciscoes, alewives, and gobies and will also eat crustaceans, insects, plankton, small birds and mammals.

Lake Trout serve as both a sport and food fish in the Great Lakes. Overharvesting by commercial fishing, the ravaging effects of the invasive sea lamprey, and chemical contamination critically lowered their populations into the 1960's. Lake Trout are making a substantial comeback in recent years due to better control of the sea lamprey and improved fisheries management.

Brook Trout

Brook Trout are another species native to the Great Lakes and were also stocked to populate many northern rivers, streams, and inland lakes of the region. A unique anadromous population named Coasters live in Lake Superior and migrate in the fall to spawn in home rivers and streams. Brook trout prefer cold clean waters and are a bellwether in determining the quality of water. Brook Trout range in adult size from 8" to 14" with Coasters weighing up to six pounds or more. Brook Trout eat aquatic and terrestrial insects along with other smaller fish, invertebrates and small mammals such as voles.

Brook Trout are often pushed out of their habitat by introduced species such as Brown Trout, and threatened by pollution that changes the chemical makeup of the waters in which they live. Brook Trout are a favorite of fly fishing anglers because they readily take an artificial fly and provide an excellent streamside meal. The restoration of Brook Trout habitat has become a major undertaking for organizations such as Trout Unlimited and, as a consequence, has improved the water in which they can once again thrive.

SALMONID FISH SPECIES (cont.)

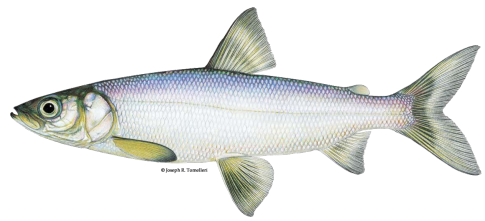
NATIVE SPECIES [cont.]

Lake Whitefish

Lake Whitefish are native to the Great Lakes and a favorite commercial catch. Whitefish are a reclusive species, enjoying very deep, cold reaches of the Great Lakes. Whitefish prefer to run in schools which makes them an easier target for commercial fishing, and their flavorful taste is enjoyed by many. Sport anglers who learn the special skills needed to catch the whitefish are sure to be rewarded by their efforts. Whitefish are early winter spawners in shallow rock or sandy-bottomed areas, and the fry head to deeper waters in the spring.

Whitefish eat insects, freshwater shrimp, small fish and fish eggs because of their small soft mouths. Whitefish have in the past been overharvested, but because of better fishing and environmental practices, are returning to improved and sustainable numbers.

Cisco



Cisco are another native fish to the Great Lakes and often called Lake Herring. Cisco and Lake White Fish are salmonid fish in the same genus of Coregonus. Many variations of both Cisco and Lake White Fish exist and identifying these species can be difficult and controversial. The snout of the Cisco and its lower jaw are equal in length, while the snout of the Lake Whitefish typically overhangs the lower jaw. There are also some differences in the size and arrangement of fins. Cisco are consistently smaller than whitefish with a record weight in Michigan of just over 6lbs. Cisco have also suffered from overharvest and the effect of invasive predators eating their eggs.

Ciscos in Grand Traverse Bay have adapted to primarily feed on gobies and smelt, and are now attaining sizes not previously seen, and are becoming a highly popular sport fishery. While they can tolerate warmer temperatures than many of the trout, they spend the vast majority of the year in cold waters.

SALMONID FISH SPECIES (cont.)

INTRODUCED & WILD SPECIES

Brown Trout

Brown Trout are an introduced species to the Great Lakes Region from Europe and have become a self-sustaining wild species of trout in many rivers. Brought to the United States in the 1880's, Brown Trout have become a favorite of sport and fly fishermen in the Great Lakes. Brown Trout are voracious eaters, feeding during the day and night, and will survive on almost any type of available food. Brown Trout range in adult size from 12" to 30", while lake run fish can attain very heavy weights. In 2009, a 41.45-pound, 44-inch, world record brown trout, a migrant from Lake Michigan, was caught in the Manistee River.

Brown Trout are fall spawning and often susceptible to inappropriate angling methods which can have a drastic effect on their reproduction. While Brown Trout are not a native species to the Great Lakes Region, restoring the coldwater habitat in which they can thrive became the primary reason for the creation of Trout Unlimited. The thrill of catching wild fish can never be replicated by hatchery fish.

Rainbow and Steelhead Trout

Rainbow Trout and Steelhead are native to the American West Coast and Canada. They are another introduced species to the Great Lakes. The anadromous type of Rainbow Trout is called Steelhead and, while sharing the same genes as a Rainbow Trout, Steelhead have a very different life cycle. Imported from California to the Great Lakes Region in the late 1870's, Rainbow Trout and Steelhead have become an important part of the sport and food fishery. Like Brown Trout, Rainbow Trout are opportunistic feeders though they tend to be less piscivorous in nature. Adult Rainbow Trout range in size from 10" to 24" while their Steelhead cousins can attain weights up to 25 pounds after spending two to three years of foraging in the Great Lakes. Rainbow Trout and Steelhead spawn in the spring, using the cold flowing fine cobble bottom stretches of their home rivers and streams.

Many self-sustaining populations of Steelhead are found in the Great Lakes. Each year a good number of these trout are intercepted, and the eggs and sperm are collected for hatchery rearing. The resultant fish are then planted in many other adaptable rivers and lakes, providing a great sport fishery.

SALMONID FISH SPECIES (cont.)

INTRODUCED & WILD SPECIES (cont.)

Chinook Salmon

Chinook (King) Salmon are the dominant salmon species of sport fishing in all the Great Lakes, creating billions of dollars of income to the region. Chinook salmon can achieve weights of over 40 pounds and are fantastic fighters on rod and reel tackle.

Chinook Salmon were introduced in the Great Lakes from the Pacific Coast almost 150 years ago, but it wasn't until 1967 when they were planted in Michigan that they became truly established as a wild self-sustaining species. Chinook salmon smolts leave rivers their first year to live in the Great Lakes for 3-4 years before returning to spawn.

Chinook Salmon are dependent on alewife as a food source. Alewife is an invasive species to the Great Lakes in need of control; the salmon contributed to this purpose. Stocking of the Chinook Salmon continues in the Great Lakes but has become more limited because of the dwindling supply of alewife.

Coho Salmon

Coho Salmon are another transplant from the Pacific Coast and were first introduced to the Great Lakes in 1966. They quickly became a favored sport fish as they are easily agitated to take lures and bait and are good fighters. The average Coho ranges from 5 to 11 pounds and feed mostly on smelt and alewives but will take other species of small fish such as gobies when available.

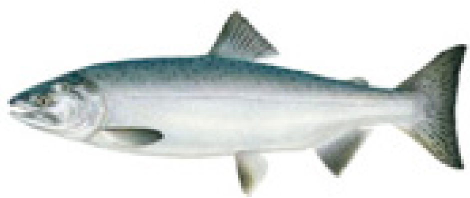
Coho smolts stay in the rivers for at least one year before making their run to the Great Lakes, returning to spawn after only two to three years, making them one of the most shortly lived species of salmon. Populations of Coho Salmon are by and large provided by stocking, but some natural reproduction does occur.

TROUT UNLIMITED

SALMONID FISH SPECIES (cont.)

INTRODUCED & WILD SPECIES (cont.)

Pink Salmon



Pink Salmon were unintentionally introduced into the Great Lakes in the 1950's and thrive primarily in the Lake Superior region and St. Mary's River rapids and are spreading to the upper regions of Lake Huron, Lake Michigan and even as far as Lake Erie. Pink Salmon are the smallest variety of salmon and mature fish can weigh from 2-4.8 lbs. on average, feeding mostly on other smaller fish species.

Pink Salmon are also called Humpback salmon due to a large hump which forms on the males during the fall spawning period. Pink Salmon smolts immediately travel to the big lake and have only a two-year life cycle, making it the shortest lived of the salmon species.

Atlantic Salmon

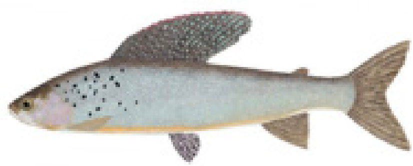
Atlantic Salmon are a highly sought-after game and food fish and were a native to Lake Ontario until it was extirpated before 1900. They were reintroduced into the Great Lakes in 1972 and are currently being stocked from sources obtained from the St. Mary's River fishery in rivers and lakes around Michigan. Atlantic Salmon are opportunistic eaters and will take crustaceans, smelt, alewives and other available food. Sizes of the fish vary, but a typical first-time returning fish can weigh on the average of 6 lbs., with record sizes in salt water of over 100 lbs.

Unlike Pacific salmon, Atlantic Salmon do not die after spawning and can return many years to reproduce in their home rivers. Atlantic Salmon are exciting fighters and can often provide aerial acrobatics.

SALMONID FISH SPECIES (cont.)

REINTRODUCED SPECIES

Arctic Grayling



A native to Michigan, the Arctic Grayling were at home in 20 Michigan rivers and extirpated almost 100 years ago. The last known Arctic Grayling was caught in the Otter River in Michigan's Upper Peninsula in 1936. Since then, several unsuccessful attempts have been made to reestablish the Arctic Grayling with the failure of natural reproduction being the main issue.

Now, a group of forty organizations is embarking on the long road to the reestablishment of Arctic Grayling in Michigan. Led by the Little River Band of Ottawa Indians, the Michigan DNR and an energetic group of PhD students, the task to reestablish the Arctic Grayling is well at hand. Eggs from Alaskan Grayling will be brought to Michigan and reared to a brood stock that will provide eggs for Remote Site Incubators placed in well selected areas of adaptable rivers and streams. This will take several years to occur, but maybe success will come, and we will once again have the presence of beautiful Arctic Grayling in their native habitat.

IMPORTANT GREAT LAKES PROGRAMS & AGREEMENTS

GREAT LAKES RESTORATION INITIATIVE [GLRI]

Introduction: The Great Lakes Basin spans approximately 300,000 square miles, encompassing all of Michigan and parts of Illinois, Indiana, Minnesota, New York, Ohio, Pennsylvania, Wisconsin, and the Canadian provinces of Ontario and Quebec. The scale and cross-jurisdictional nature of the resource requires significant funding and collaboration to enable the on-the-ground conservation work necessary for restoring the health of the Lakes. The mechanism for accomplishing this and the primary driver of conservation delivery in this region is the Great Lakes Regional Collaboration/Great Lakes Restoration Initiative (GLRI). These programs have enjoyed great bipartisan support and diverse partnerships among federal, state, local, tribal, business, and NGO groups, united under restoring the health of the Great Lakes.

Details: The need for restoration funding for the Great Lakes has been recognized for decades, indicated by the signing of the Great Lakes Water Quality Agreement by the U.S. and Canada in 1972 which aimed to restore, protect, and enhance water quality of the lakes and promote ecological health of the basin. Government commitment to maintaining the integrity of this resource continued to evolve from there, leading to the creation of an interagency task force and Great Lakes Regional Collaborative Strategy and the issuance of a Presidential Executive Order calling the Great Lakes a "national treasure," by President George W. Bush. President Barack Obama took it from there and his administration helped develop the GLRI and Congress then acted in 2010 to appropriate money to the Initiative by using the Great Lakes Regional Collaboration Strategy of 2005 as a roadmap to guide investment decisions. Funding has continued at $300 million per year since 2010, and the program continues to enjoy great bipartisan support in Congress.

GLRI represents a collaborative effort by 16 different federal agencies, as well as state and local governments, tribes, and many other private organizations and partners working together to target the following priorities:

1. Cleaning up toxic substances and Areas of Concern (AOC)
2. Preventing or removing aquatic invasive species
3. Improving nearshore health and preventing nonpoint source pollution
4. Restoring and protecting habitat and wildlife
5. Evaluating and monitoring progress

IMPORTANT GREAT LAKES PROGRAMS & AGREEMENTS (cont.)

GREAT LAKES RESTORATION INITIATIVE [GLRI] (cont.)

Points of Interest:

- **4,203 GLRI** funded conservation projects since 2010
- **27** Areas of Concern (AOC) remain
- GLRI projects often feature a **3:1 ratio return in matching funds** from private donors, local agencies and non-profit organizations like TU
- **$6** return in the form of increased fishing, tourism and home values for every **$1** invested in Great Lakes restoration

The GLRI is producing results throughout the Great Lakes Basin. In Wisconsin, the GLRI has supported a $750,000 investment in infrastructure to improve fish passage in and around the Nicolet National Forest. Michigan has received funding to improve the Rogue, Pere Marquette, Manistee, and Little Manistee rivers, and Minnesota has benefited from projects on Lake Superior tributaries like the Sucker River and Stewart River, just to name a few Trout Unlimited initiatives. Program authorization and appropriations are subject to political forces and therefore dependent on the steadfast support of legislative leaders and constituents from the Great Lakes region and beyond to advocate for the continuation of this critical initiative. GLRI has historically enjoyed strong bipartisan support and in order for that and subsequent robust funding to continue, anglers must send a clear message to members of Congress that this program is essential for the future health of the region.

IMPORTANT GREAT LAKES PROGRAMS & AGREEMENTS (cont.)

THE GREAT LAKES COMPACT AND WATER WITHDRAWALS

Introduction: Demand for drinking water is rising in the United States and around the world due to population growth. At the same time, existing supplies of water are being strained by pollution, overconsumption, and drought, and may be strained further in the future by climate change. As these trends continue, communities and countries around the world will seek new sources of water and one place they will look to is the Great Lakes. Yet for all their size, the Great Lakes are nonetheless finite and vulnerable. Just as even a large bank account can be depleted by overspending, the Great Lakes can be depleted if more water leaves than enters them. However, if the water "bank account" is kept in balance, the Great Lakes—and the diverse ecosystem and large regional economy they support—can be sustained. The Great Lakes Compact is an unprecedented, multistate agreement aimed at protecting the Great Lakes from "overspending."

Details: Under the Compact, the eight Great Lakes states agree to adopt water-conservation plans and to abide by Compact rules for allowing and managing diversions of Great Lakes water. The Compact recognizes the lakes as a shared resource which no single state owns but, of which, all states are stewards. As such, a defining feature of the Compact is its emphasis on using regional cooperation to manage the lakes as a single ecosystem. Unveiled in Milwaukee in December 2005, the Compact is the product of five years of negotiations between states, Canadian provinces, tribes, businesses, environmental groups, municipalities, water managers, scientists, lawyers, and the public. In 2007 and 2008, the Compact was approved by the legislatures of the eight Great Lakes states and by Congress. The Compact was signed into law by President Bush on October 3, 2008.

At the heart of the Great Lakes Compact is a water management approach known as whole basin management. A basin is the area of land that naturally drains to a particular river, lake, or other type of water body. Under the whole basin management approach, a water resource is managed as a whole system, defined by these natural basin boundaries. Whole basin management helps protect the integrity—and therefore the health—of a water resource. The main way in which the Compact applies this management approach is through provisions aimed at minimizing the amount of Great Lakes water that is unnaturally diverted out of the Great Lakes basin, never to return to the lakes. The Compact also contains provisions promoting the conservation and efficient use of Great Lakes water inside the Great Lakes basin. In addition, it sets guidelines for assessing the effectiveness of these management strategies.

ASIAN CARP

Introduction: Asian carp are an invasive species that poses a threat to the Great Lakes, both environmentally and economically. Our $7 billion annual Great Lakes sport fishery is at risk if these invasive species enter Lake Michigan through the Chicago River.

A plan to address the issue of Asian Carp has been proposed by the Army Corps of Engineers. The Brandon Road Lock and Dam includes both structural and nonstructural measures including an engineered lock fitted with an electric barrier, a bubble barrier, an acoustic barrier, and a flushing lock to stop aquatic invasive species like Asian carp, while maintaining navigation for shipping. The Brandon Road Lock and Dam is located just south of Chicago and is a critical chokepoint to help stop Asian carp from continuing to swim closer to Lake Michigan.

Details: Asian carp is a term used to describe four different species of carp: bighead, silver, black and grass. In the 1960s, sterile Asian carp were imported to the American South as a means to eradicate vegetation in isolated ponds and water impoundments on golf courses and at housing developments. At the time, the use of chemicals and herbicides to curtail the growth of aquatic plants was being scrutinized for being harmful to the ecosystem and human health, and carp were seen as an eco-friendly alternative. However, periodic flooding connected these water bodies to streams and rivers, allowing the carp to travel into larger watersheds. This, coupled with the fact that many imported carp were not actually sterile and could reproduce, led to an established breeding population in the Mississippi River. Since then, these carp have made their way north up tributaries and into the larger watershed. Of particular concern are the impacts that Asian carp have on native fish populations. In some stretches of tributaries flowing into the Mississippi River, fish poplulations have been reduced by over 80%.

There is a lot of concern regarding a possible carp invasion into Lake Michigan by way of the Chicago Area Waterway System (CAWS). The Brandon Road Lock and Dam is the last barrier holding back the onslaught of bighead and silver carp, though sporadic captures of carp beyond Brandon Road have occurred. The lock is only a few miles from Lake Michigan, just outside Chicago. The US Army Corps of Engineers has put together an action plan that calls for $778 million in spending on a number of control measures at Brandon Road. This cost would be split between the federal government and initially the state of Illinois. The former governor of Michigan, Rick Snyder, indicated that Michigan would help pay the state obligation, lessening the cost for Illinois.

ASIAN CARP (cont.)

Currently, only Lake Erie is believed to have a breeding population of the invasive grass carp. These fish have primarily been found in southeastern Lake Erie near Maumee, OH. However, grass carp continue to be caught farther and farther away from the Ohio epicenter, suggesting the population is expanding. Grass carp can grow up to 5 feet long and weigh 80 pounds. They feast on submerged aquatic vegetation and can consume between 20% and 100% of their body weight every day, putting them in direct competition with endemic fish, waterfowl and invertebrates. In Lake Erie, a number of eradication strategies have been discussed, but efforts there continue to be based around research of this carp population rather than action.

Points of Interest:

- The Great Lakes sportfishing industry is at risk from invasive Asian carp.
- The Brandon Road Lock and Dam is the only viable solution to preventing Asian carp from reaching Lake Michigan.
- If Asian carp reach Lake Michigan, our sport and commercial fishing industry will rapidly decline.
- A decline in the fishing industry due to Asian carp would have a devastating impact on the local and state economies.

OTHER INVASIVE SPECIES

Invasive species have been introduced to the Great Lakes ecosystem and have produced significant negative impacts on cold water species. Given that the Great Lakes basin is a complex system, even minor changes to the hydrology or food web can have major impacts in unpredictable ways. According to Dan Egan, author of The Death and Life of the Great Lakes, by 2017 the count of invasives had reached 186, each with its own story of disruption. The dramatic decline of the native lake trout offers one example of the rapid negative impacts that invasives can have upon this complex watershed.

SEA LAMPREY

Lake Trout were the apex predators within the Great Lakes centuries ago. Subspecies variation allowed the proliferation of many different stocks to share these waters and some grew up to 70 pounds in size. Abundant catches were recorded throughout the industrial expansion of the late 19th and early 20th century. The sea lamprey was first detected in the mid-1930's and was believed to have entered through man-made shipping canals. Within a decade, lake trout stocks began to fall; Lake Michigan's annual catch fell from 6.5 million pounds in 1944 to just 342,000 pounds by 1949. The sudden impact of the sea lamprey decimated the lake trout populations and is still felt today.

A new vector for previously isolated predators, like the sea lamprey, was opened when the St. Lawrence Seaway began permitting inbound vessels that originated from around the globe in 1959. As global trade began sailing these inland waters, tiny invasive hitchhikers came along for the ride in ballast water tanks. And once a new invasive is introduced, inter-lake shipping can play a role in speeding the distribution of a new species throughout the basin.

ALEWIVES

The impact of the sea lamprey played a critical role in decimating the commercial fishery for lake trout in the middle of the last century. But another invasive also contributed to this decline, a small prey fish called the alewife. These prey fish, when consumed by lake trout, caused deadly development problems in lake trout offspring. Once this apex predator was effectively removed from the food web, the alewife was left unchecked and began the next dramatic boom cycle. Alewives are a saltwater herring and remain stunted in the freshwater environment. Yet alewives proved capable of incredible reproduction without an apex predator. Rapid temperature swings, common to the Great Lakes, can cause massive die-off events that result in beaches covered in mounds of rotting finger-length fish. In approximately two decades, a change to the shipping trade routes resulted in the introduction of the lamprey, decimation of the lake trout population, and a new invasive herring which could overpopulate the basin.

OTHER INVASIVE SPECIES (cont.)

ALEWIVES (cont.)

The sea lamprey would become a perennial nuisance that requires regular mitigation treatments throughout the watershed. Ironically, the alewives have been held in check by the introduction of other non-native salmonids (Chinook and Coho). Alterations to shipping channels can be important vectors for invasive species and must be carefully considered. As we have learned from the invasive quagga mussel, problems within the basin can quickly develop into issues that affect cold water fisheries far beyond the basin.

QUAGGA MUSSELS

The quagga mussel offers a frightening window into how rapidly a Great Lakes problem can become a national one. In 1989 the first quagga mussels were found in Lake Erie. Known as an invasive threat in European waters since the 19th century, zebra and quagga mussels were not seen in the United States until the late 1980's. They are believed to have entered in ballast water from an inbound vessel. Since the ports of the Great Lakes are just two stops from 99% of all seaports across the globe, problems can travel the globe in days. Quagga mussels quickly established across Lakes Erie, Huron, and Michigan. These mussels consume plankton, and their effects on the food web are immediate. They even contribute to the crash of alewives, another invasive plankton eater. The viral growth of invasive mussels filter and clarify the water column, which has an interactive effect with the native flora. Without a native predator, they have rapidly colonized the sea bed of Lake Michigan from shore to shore. By the early 1990's, Quagga migrated out of the basin via the change in hydrology created by the Chicago shipping canal, and quickly travelled in the Mississippi River watershed. They have an ability to travel upstream by attaching to nearly anything. They also have the unique ability to survive out of water, meaning that anglers provide a vector for transport when traveling between watersheds.

OTHER INVASIVE SPECIES (cont.)

DIDYMO (Rock Snot)

Didymo is a microscopic freshwater diatom (a type of algae) that secretes a fibrous stalk which it uses to attach itself to rocks and plants in rivers and streams. During blooms, the stalks grow to form thick mats that can completely cover the stream bottom. This disgusting diatom may look slimy, but its silica cell walls make it feel more like wet wool. Nuisance blooms are often mistaken for raw sewage spills since trailing stalks look like wet toilet paper in the water.

Under optimal growing conditions, didymo forms dense mats that can completely envelop the stream bottom, smothering aquatic plants, insects and mollusks, and reducing fish spawning and foraging habitat. Nuisance blooms of didymo may cause a shift in the benthic macroinvertebrate community from caddisfly, mayfly and stonefly (an important food base of many trout and native fish species) to midges and worms. Didymo may outcompete or limit the growth of native algal species that are a food source for aquatic insects. Didymo may also have harmful effects on the local economy. Stalk material can clog irrigation canals, block pipes and water intake structures at hydropower facilities, hinder commercial and sport fisheries, and ruin the aesthetic value of a water body, which may impact recreational and tourism industries. Mats of didymo can grow up to 12 inches thick on the stream bottom with strands trailing in length of up to three feet.

NEW ZEALAND MUDSNAILS

The New Zealand mudsnail is a tiny aquatic snail that inhabits lakes, rivers, streams, reservoirs and estuaries. In addition to mud, the snail can also be found lurking on rock or gravel surfaces, aquatic vegetation, or woody debris. New Zealand mudsnails are highly adaptable to diverse climates and can tolerate a broad range of aquatic conditions such as temperature, salinity, turbidity, water velocity, and stream productivity. In the United States, New Zealand mudsnail populations are comprised almost entirely of self-cloning parthenogenetic females (no need for fertilization). The brood size of an individual female ranges from 20-120 embryos, each of which may mature to produce an average of 230 offspring per year. A single female mudsnail can result in a colony of 40 million snails in one year.

OTHER INVASIVE SPECIES (cont.)

NEW ZEALAND MUDSNAILS (cont.)

The high reproductive potential of the New Zealand mudsnail enables it to reach extraordinary densities in some locations. Researchers at Montana State University have reported densities of up to 750,000 snails per square meter in Yellowstone National Park. Large colonies of New Zealand mudsnails can comprise up to 95 percent of the total macroinvertebrate biomass and consume up to half of the available food in a stream. New Zealand mudsnails may outcompete or displace native snails, mussels, and aquatic insects which native fish species depend on for food. This disruption of the food chain may ultimately result in reduced growth rates and smaller populations of economically important fish species.

BALLAST WATER DISCHARGE

Introduction: Ballast water is the water used in a ship's internal tanks for stabilization and improves their overall function. Ships take on ballast water while unloading cargo or during troublesome weather to stabilize and balance out the weight of the ship. Often when taking on water for stabilization, ships inadvertently take on unwanted aquatic species which are later discharged into distant waters. The transport of these species in ballast water has led to the establishment of invasive species in some of the most treasured and valuable of ecosystems.

Details: Aquatic invasive species have wreaked havoc on the Great Lakes for over a century and according to the Environmental Protection Agency (EPA), thirty percent of invasive species in the Great Lakes have been introduced through ship ballast water. The discharge of ballast water into the Great Lakes has led to the pervasive establishment of notable invasive species such as quagga and zebra mussels, spiny water fleas and round gobies. These four species have spread to all five Great Lakes and have had a significant impact on the Great Lakes watershed. The US Fish and Wildlife Service has estimated that nonnative species borne in the ballast or hulls of ships cost the Great Lakes Region $500 million annually to control.

Originally introduced in the ballast water discharged by oceangoing vessels originating in Europe and Asia, these invasive species can be, and have been, spread from infested ports in the lower Great Lakes to Lake Superior by ships operating entirely within the Great Lakes. These intra-Great Lakes ships are called "lakers," but should not be confused with our amazing native lake trout (Salvelinus namaycush) which are affectionately referred to by the same moniker. The Minnesota waters of Lake Superior receive more than half of all ballast water discharges in the entire Great Lakes. The aquatic invasive species are eventually spread from Great Lakes ports by recreational boaters, bait buckets, etc., and end up in our inland waters. The list of inland lakes whose fisheries have been upended by invasive critters like zebra mussels continues to grow. Many will be spread to inland trout lakes and streams.

Ballast water discharges are regulated by the EPA under the Clean Water Act. Federal agencies have been slow to meaningfully regulate ballast water discharges and have elected not to regulate discharges from "lakers" at all. One feature of the Clean Water Act is that individual states can elect to adopt their own regulations for state waters via "401 Certification," when they believe the national regulations are not protective enough. Beginning in 2008, the State of Minnesota adopted its own ballast regulations which, importantly, apply to all large vessels including "lakers."

AQUACULTURE

Introduction: Aquaculture is the controlled cultivation of aquatic animals and plants. It refers to the breeding, rearing, and harvesting of plants and animals in all types of water environments, including tanks, ponds, rivers, lakes, and the ocean. Aquaculture is used for a variety of purposes including producing seafood for human consumption; enhancing wild fish, shellfish, and plant stocks for harvest; restoring threatened and endangered aquatic species; producing sportfish and baitfish for commercial and sport fisheries; and providing fish for aquariums

Details: There are four main types of aquaculture facilities: net-pen, flow-through, pond and recirculating. Net-pen aquaculture is the practice of raising fish in an underwater net or structure that serves as a pen. Found offshore in coastal areas or in freshwater lakes, open net-pens or cages are considered a high-risk aquaculture method as they allow for free and unregulated exchange between the farm and the surrounding environment.

Flow-through systems involve the continual flow of a high-quality water source through a tank or channel called a raceway. The constant flow of water helps provide oxygen to the system while removing wastes. Flow-through systems provide waste treatment as required, and then discharge the water rather than treating and recirculating it.

Pond cultures are the most common aquaculture production system. An aquaculture project can consist of only one pond or hundreds of specially designed ponds. The size of the pond varies depending upon its purpose. It is designed to meet the natural environmental requirements of the fish being raised and the natural growth of aquatic organisms provides a natural food for the fish and makes the pond an attractive habitat for other aquatic animals. This form of aquaculture led to the escapement of invasive Asian carp that now threaten the Great Lakes.

Recirculating aquaculture systems are indoor, tank-based systems in which fish are grown at high density under controlled environmental conditions. Recirculating systems are the most expensive means of culturing fish, but also the most environmentally friendly. Advantages of recirculating systems include: tight control of the temperature, flow, and water quality to ensure optimum rearing conditions, a high level of biosecurity, minimizing the chance of fish escaping into the wild, disease prevention, less water use than other aquaculture systems, can be located in more areas and generate year-round production.

TOXIC ALGAL BLOOMS

Introduction: Toxic algae blooms have become a global problem and are associated with three forms of cyanobacteria: Anabaena, Aphanizomenon, and Microcystis. These primitive forms of bacteria are not new – but they are thriving where nutrient rich waters allow blooms to create toxic conditions for humans and wildlife. Exposure warnings are now a frequent occurrence nationwide, from northern lakes to the southern rivers. Phosphorus is the growth limiting nutrient for cyanobacteria blooms; progress towards controlling toxic algae means controlling the phosphorus nutrients that enter the watershed.

Phosphorus, the eleventh most common element on earth, is essential for all forms of life. Global production from phosphate mines is the dominant source for phosphorus production. 260 million tons were mined in 2016 and ninety percent of that is used for fertilizer production and food processing. Prior to passage of the Clean Water Act, phosphorus contamination from industrial and municipal sources were significant contributors (point sources). Phosphorus loading of degraded waters is now predominantly a result of agricultural runoff (non-point sources). Soil erosion is a major contributor of phosphorus to streams. Bank erosion occurring during floods can transport a lot of phosphorus from the river banks and adjacent land into a stream. Progress on controlling toxic algae means controlling the agricultural runoff that enters the watershed.

Details: In August of 2014, the Toledo municipal water system was closed for three days by a Microcystis bloom in the western basin of Lake Erie. Four hundred thousand residences were forced to use bottled water to avoid the toxic effects. That bloom was visible from space. Lake Erie is uniquely susceptible to the recent growth of toxic algal blooms, due to its relatively shallow depth and predominance of agricultural drainage. However, toxic algal blooms have been reported in Lake Huron's Saginaw Bay, western Lake Michigan, as well as tributaries to Lake Michigan. Recently, cyanobacteria were detected in a bloom in Lake Superior, near Duluth, MN, following a major rain event in 2017. The source of nutrient loading is still under investigation for the 2017 Superior bloom, although agricultural runoff is not likely a significant contributor.

Contact with toxic algae can lead to liver and brain damage, and posted beaches are encountered nationwide. Yet the damage from excessive nutrient loading is not limited to toxic water. Other negative effects from nutrient-driven algal blooms result in eutrophication (accelerated aging) and broad "dead zones" devoid of oxygen. As the algae die off and fall through the water column, the decomposition process depletes the available oxygen. Aquatic life including commercial and recreational fisheries are impacted. Note that "dead zones" are a global issue and affect both fresh and saltwater environments including the Gulf of Mexico and Chesapeake Bay watersheds.

TOXIC ALGAL BLOOMS (cont.)

Trout Unlimited grew from a frustration with degraded water conditions within Great Lakes tributaries, and the loss of habitat for the trout within. Today, conditions within the Great Lakes tributaries can be directly attributed to the issue of nutrient loading of the lakes. Given that the Great Lakes basin is home to native Atlantic salmon, unique coaster brook trout, and lake trout as well as other salmonid species, TU has more than enough reason to stay engaged with other stakeholders to reconnect healthy tributaries to the lakes themselves. That will involve restoring the conditions of the lakes as well. TU can serve as an important partner together with other public and non-profit organizations to further inform policy to mitigate phosphate pollution in the trout-filled tributaries and lakes of this global coldwater resource.

CLIMATE CHANGE

Introduction: Changes in our climate are influenced by the intensity of our sun's heat and by the ability to absorb and/or reflect this heat. It appears that a slight warming trend has been taking place over the last few decades. Over the last 30 years, using information taken from the 2017 ASHRAE Handbook of Fundamentals, it shows there has been a temperature increase in the range of 0.36F to 1.08F per decade in the northern regions of the United States. There has also been a decrease in humidity in the southern United States.

Details: In the Great Lakes Region, there is a unique influence on the climate caused by the large bodies of water located in the basin. This water is a heat sink which absorbs summer heat and then tempers the weather in the winter. The opposite occurs going from winter to summer. The lakes also release large amounts of water vapor to the air as it passes over the lakes which results in significant rain and snow to adjacent areas. The climate also influences the lake levels in that very cold winters result in the lakes having a frozen top surface which limits the evaporation of water from the lakes. This complex interaction affects not only our stream and lake temperatures but also the quantity of water that exist in them.

Healthy watersheds are resilient watersheds, and a multitude of restoration actions can improve watershed resiliency and buffer against climate change impacts, such as how projects are chosen and specifically what role habitat assessments are likely to play in these decisions, how restoration efforts address climate change impacts, how local projects can achieve results at watershed scales, and how projects are monitored and evaluated.

MICRO PLASTICS

Background: Microplastics are defined as plastic fragments, beads, foams, films or fibers smaller than 3mm in size. The persistence of microplastics in the natural environment is a direct outcome of one key design attribute: resistance to natural decomposition. Since the widespread introduction of plastics in the 1950's, worldwide annual production has increased to 322 million tons (2015)1. As this material is introduced to the natural environment, embrittlement from photo-degradation and mechanical breakdown turn macro-plastics into micro-plastic waste.

Many Americans are aware of the Great Pacific Garbage Patch between California and Hawaii. Microplastics within just this one patch of ocean account for an estimated 6300 tons (and 1.7 trillion individual particles) spread across an area twice the size of Texas. Microplastics are more than just an aquatic nuisance; these tiny fragments are showing up in our food stream, in the form of sea salt, tap water and bottled water and beer. Recent studies reveal that the Great Lakes have reason to be concerned as well.

Details: The Great Lakes are the source for drinking water for an estimated 40 million residents of the watershed. Additionally, the Great Lakes Region is home to dozens of the best microbreweries in the nation. However, a study published in 2018 highlighted the presence of microplastics in Great Lakes beers. Other recent studies by Professor Sherri Mason (SUNY – Fredonia) have begun to document the presence and cumulative effect of microplastics as water flows downhill from Superior, through Michigan and Huron, and out through Erie and Ontario towards the sea.

The threats from plastic pollution are substantial:

> *Microplastics pose a health risk to aquatic animals, including fish, turtles, and birds, because of possible entanglement and ingestion… Ingestion of plastic may cause internal bleeding, abrasion and ulcers, as well as blockage of the digestive tract… Plastic debris may act as a vector for contaminants, including persistent organic pollutants (POPs) and heavy metals… Sorption to plastics has been shown to limit the biodegradation of organic contaminants, increasing their persistence in the environment… Plastic debris can also transport non-native species … and be colonized by microbes including possible pathogens… In littoral zones, the accumulation of sinking plastic debris and the dragging of fishing nets may disrupt bottom sediments, displace or smother infauna, and affect the structure and functioning of benthic microbial communities...*

MICRO PLASTICS (cont.)

Recent studies have revealed that the concentration of microplastics in the Great Lakes tributaries can be significantly higher than that of the lakes themselves. And as we all are aware, concern for these same watersheds drove the founding of TU decades ago. In fact, TU was founded shortly after LIFE Magazine documented our new fascination with a "Throwaway Lifestyle" aimed at reducing household chores through disposable plastic goods. Further study into the major sources and likely solutions to this vexing problem are needed; TU can serve as an important partner together with other public and non-profit organizations to further inform policy to mitigate microplastic pollution in the trout-filled tributaries and lakes of this global coldwater resource.

PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)

Introduction: PFAS (Perfluoroalkyl and Polyfluoroalkyl Substances) are a group of chemicals used in waterproofing, firefighting and household cleaners. These substances are predominantly found in high concentrations around military bases and airports. PFOS and PFOA are the most prevalent of the PFAS group of chemicals. In high concentrations or high exposure levels, PFAS can carry large public health risks. Recently, PFAS has gained a lot of attention in Michigan as it has been found in high concentrations in water in a few parts of the state.

Deatils: PFAS substances are a group of nearly 5,000 chemicals that were initially created by DuPont in the 1930's. Since then, many companies, like 3M, have used these chemicals for a range of products, including Teflon, firefighting foam and waterproofing shoes and boots. These substances are known as the "forever" chemicals because they have very strong bonds that don't break down and can exist in the environment and in human bodies for a very long time.

As the long-term effects of PFAS exposure on people is still being studied, it is believed that the chemicals can affect growth and development of children, interfere with a woman's chance of getting pregnant and increase risks of cancer.

Points of Interest:

- PFAS chemicals are found in high concentrations and close proximity to airports, military bases and shoe factories. Michigan has found that fish and deer that live near these areas can have high levels of PFAS contamination.
- A 70 parts per trillion concentration is considered hazardous to human health by the EPA.
- The chemical has been found in high concentrations in localized fish populations and one deer to date in Michigan.
- Additional studies may be done to determine more widespread risks to other species of animals and birds, such as waterfowl and turkey.

OIL TRANSPORT

Introduction: Large crude oil and natural gas pipelines crisscross the Great Lakes Region along with rail transport of similar products. The growth of oil production in the north central United States and western Canada, much of which is transported to 11 refiners throughout the Great Lakes basin, has created many potential threats to several aquatic ecosystems. Moreover, along with these threats, comes the need to be able to effectively respond to an actual spill or pipeline rupture.

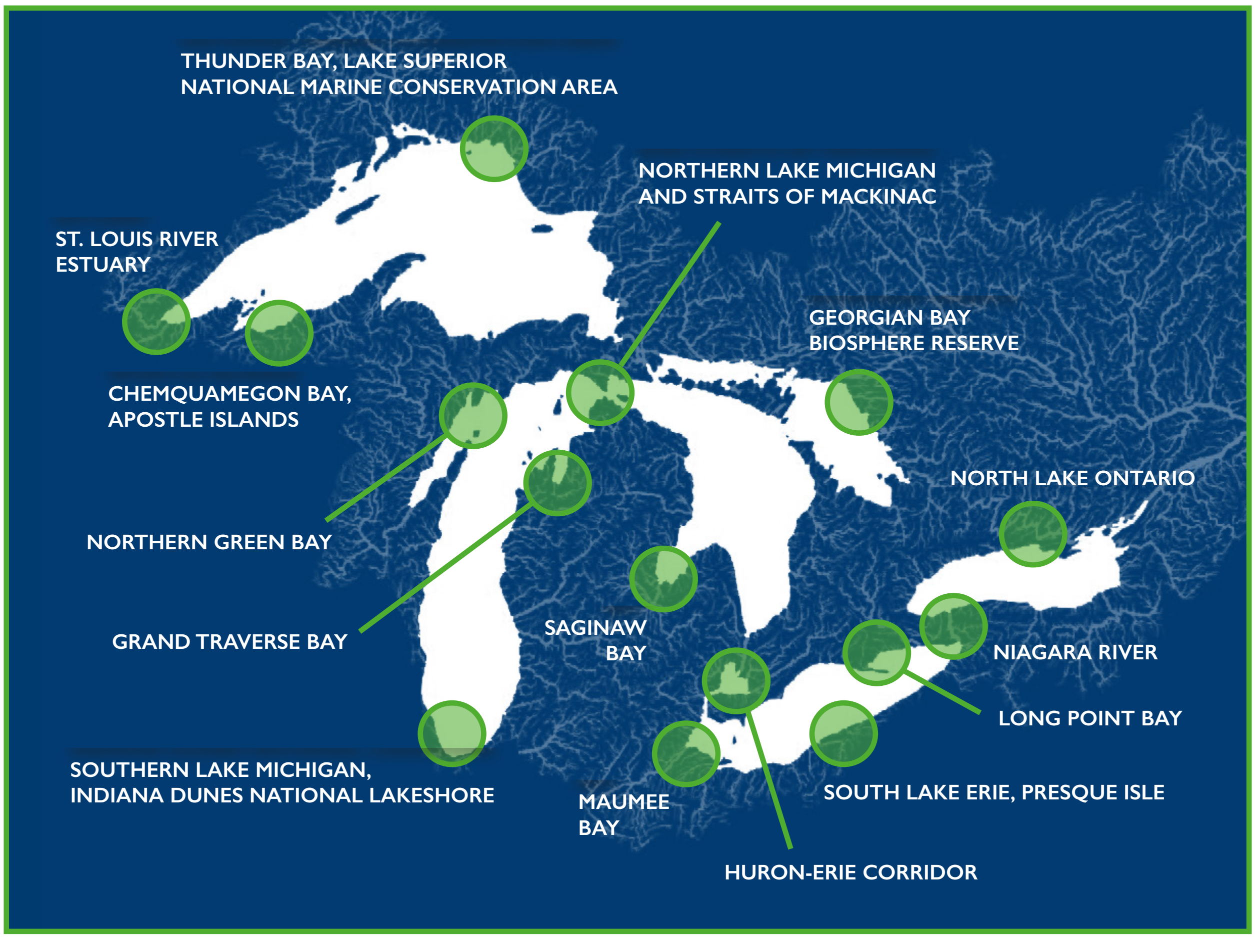
Details: The most immediate and highly controversial peril to the Great Lakes basin is the Enbridge Line 5 pipeline. Enbridge Line 5 is a massive 645-mile-long system that moves 23 million gallons of petroleum products per day from Superior, Wisconsin through Michigan to Sarnia, Ontario. According to Enbridge, Line 5 delivers 65% of the Upper Peninsula's propane and 55% of Michigan's propane needs. The pipeline was constructed in 1953 making it increasingly more susceptible to failure. The lingering problem with Line 5 is that it crosses the Straits of Mackinaw. As the line heads south from the Upper Peninsula north of Mackinaw City, its 30-inch diameter trunk splits into two 20-inch branches that lie on the bottom of the Straits until reaching Mackinaw City on the Lower Peninsula. There is the fear that this pipeline is outdated and could create an environmental disaster in one of the Great Lakes' most ecologically sensitive areas. Line 5 has spilled 29 times since 1968; fortunately, none of these spills occurred under the Straits. Because of the extremely strong bidirectional currents through the Straits, a rupture in Line 5 would cause severe effects on the drinking water, fish and wildlife, and the economies from Beaver Island in Lake Michigan to Rogers City and lower Lake Huron. In 2018, a near disaster was caused by a barge hooking Line 5 and several nearby electrical conductors with its anchor denting the pipeline, creating even more concern.

As a solution to the aging Line 5 pipeline crossing, a utility tunnel under the Straits of Mackinaw has been proposed by Enbridge. The proposed construction has created its own set of environmental, political and legal issues. Recently, Michigan's Attorney General filed suit to close down the pipeline. If lawsuits don't delay the construction of the tunnel it will still take up to 5 years to complete the construction and, in the meantime, the Line 5 threat remains viable.

OIL TRANSPORT (cont.)

Enbridge Line 5 is only one threat among many pipelines in the Great Lakes Region. Many other pipelines and rail lines in similar or worse condition cross many of the majestic rivers and course closely to vulnerable lakes and wetlands. As an example of what can happen, Enbridge Line 6B ruptured on July 26, 2010, leaking 840,000 gallons of oil sand crude from the pipeline in Calhoun County, Michigan into Talmadge Creek, which flows into the Kalamazoo River. The spill continued unabated for 17 hours, creating an environmental disaster and cleanup that has only recently been concluded at a total cost of $1.3 billion dollars. This disaster could just have easily been in a coldwater river or under the Straits of Mackinaw.

Oil Spill Threats in the Great Lakes



Information from International Joint Commission Great Lakes Science Advisory Board report/Illustration by A.J. Jones

FRACKING & FRACK SAND MINING

Introduction: High-Volume Hydraulic Fracturing (HVHF or fracking) is a method of injecting large volumes of water mixed with proprietary blends of chemicals comprising the frack fluid that contains proppants-solid material such as sand, treated or coated sand, or ceramic materials into oil and gas wells. This is done to stimulate production in older wells or to release hydrocarbons that are in geologically "tight" formations. The fracking fluid is injected at up to 15,000 PSI into horizontal well bores branching off a vertical bore at pressures and volumes sufficient to crack the hydrocarbon-bearing rock and releasing the oil or gas into the well. Water volumes of several million gallons are used in typical fracking episodes and individual wells may be fracked multiple times.

- Fracking of shale deposits within the Great Lakes Watershed includes numerous wells in the Marcellus and Utica Shales found in Pennsylvania, New York and southern Ontario, and the Antrim Shale in Michigan.

Details: Frack fluid is used to pressurize the well, carry the proppant and, ultimately, to fracture the rock formation. Large volumes of water are mixed with a number of additives to create fluids which may be either gel-like and viscous or "slickwater-based" with low-viscosity allowing higher pumping rates used in HVHF fracks. A typical fracking episode may use 40,000 gallons of chemical additives, with 3 to 12 components in the mixture. Chemical additives to fracking fluid may include:

- Acids, a variety of salts, polyacrylamide, ethylene glycol and other chemicals are used. The most commonly used additive is methanol.
- Each fracking episode produces large volumes of "produced water" amounting anywhere between 50%-90% of the amount injected. Produced water must be collected and either stored on site, injected into disposal wells, or treated prior to being released into the environment due to the chemical additives.
- Rapid, large-scale water withdrawal often accompanies fracking operations and may affect localized groundwater and surface water conditions and negatively affect cold water resources.

FRACKING & FRACK SAND MINING (cont.)

Frack sand/roppants are solids mixed in the fracking fluid that holds the rock fractures open and allow the hydrocarbons to travel to the well bore. Sands with uniform grain size are mined from high silica content sandstone deposits within the Great Lakes and Mississippi River basins for frack sand production. The St. Peter Sandstone in northeast Illinois and western Wisconsin, the Sylvania Sandstone in southeast Michigan, and dune deposits along the eastern shore of Lake Michigan are all actively mined for frack sand. Frack sand mining and its associated environmental effects may represent the most overlooked aspect of the hydraulic fracking technique and one which can adversely affect both surface and groundwater resources.

- Frack sand mining is done in open pit mines where the sandstone deposit is close to the surface (IL, WI & MI), where it occurs as surficial sheet and dune deposits (MI), and in horizontal shaft mines (WI).
- Frack sand processing requires large volumes of water to wash and process the sand. Processed sands are then coated with resin or other materials to harden the grains to resist crushing when occupying the fractured rock, thus keeping the fractures open.
- Quantities of frack sand or other proppants remain in the produced water from wells and must be separated from the water and disposed of so as not to contaminate the environment.

SULFIDE MINING

Mineral extraction is a constant threat to the water quality of the upper Great Lakes Region. The areas of Michigan's Upper Peninsula, northern Wisconsin and northeastern Minnesota are constant targets of the mining industry seeking copper, nickel, gold and other metals.

The extraction process is called "Sulfide Mining" because of the sulfide-rich ore bodies containing the minerals in this region. The danger associated with this type of mining is that the sulfide byproducts from the product and tailings of the mine, when exposed to air and water, create sulfuric acid. The resultant liquids are called Acid Mine Drainage and when leaked into a local water resources can create long term pollution problems. Acid Mine drainage will form multi-colored sediment in the rivers and streams and harm or kill fish, benthic invertebrates and aquatic plants. Once this type of pollution occurs, the cleanup and restoration process becomes very difficult, extremely long term and very costly. The mining process also creates industrialization affects to the surrounding areas including large land clearing, new roads, truck traffic, water and noise pollution and permanent natural resource disruptions.

On a positive note, the Mining Workgroup of the Trout Unlimited National Leadership Council has produced a document called "The Mining Handbook" which is very useful to chapters and councils for helping to identify if proposed mining projects should be opposed given certain circumstances and careful review. A copy of that handbook can be found by using the link provided below:

https://www.tu.org/get-involved/volunteer-tacklebox/council-leader-resources/national-leadership-council/nlc-conservation-workgroups/mining-workgroup/

PHARMACEUTICALS

Introduction: Pharmaceuticals in the waters of the Great Lakes are becoming an increasing threat to the organisms that live in it and the human populations that consume its waters. The residual drugs are measured in parts per million and parts per billion and, as small as that might be, they have been found accumulating in and saturating the tissues of aquatic life. Studies concerning drug effects on fish and other aquatic organisms are indicating slower reaction time to predators, changed eating habits, and reproductive abnormalities.

Details: The drugs enter the rivers and lakes from improper disposal and human excrement flowing into the sewage treatment systems. In addition, consumer products such as soaps, toothpastes, fertilizers and herbicides add to the situation. According to a study done by the International Joint Commission more than 1400 waste treatment plants in the U.S. and Canada discharge 4.8 billion gallons of treated effluent into the Great Lakes basin on a daily basis. At this time, waste treatment facilities in general are not designed to completely eliminate these types of chemicals. Furthermore, there are not federal guidelines on the amount of pharmaceuticals allowed in waste or drinking water, although the EPA is studying this situation. Waste water treatment plants using activated sludge treatment, ozonation and carbon filters are more effective at removing unwanted chemicals from sewage and drinking water, but these processes come at a high price for the municipalities proposing to use them.

While it is understandable that many of these products are useful in maintaining our health, we can make efforts in the meantime to handle and dispose of these drugs and chemicals in a safer way. Unused drugs, prescription and over-the-counter, can be taken back to pharmacies and law enforcement centers for proper disposal.

LEGACY ISSUES

WETLAND LOSS

Wetlands prevent flooding by holding water, much like a sponge. In doing so, wetlands help keep river levels normal and filter and purify the surface water. When water levels are low, wetlands slowly release water, including vegetative matter into rivers, which helps feed fish and other wildlife in rivers. Wetlands also help to counter balance the human effect on rivers by rejuvenating them and the surrounding ecosystems. Many animals that live in other habitats use wetlands for migration or reproduction. While wetlands are truly unique, they must not be thought of as isolated and independent habitat. To the contrary, wetlands are vital to the health of all other biomes and to wildlife and humans everywhere. Unlike most other habitats, wetlands directly improve other ecosystems.

DEFORESTATION

In addition to the harm industrial practices did to our streams, many areas of the Great Lakes watershed were harvested for the region's trees. The cutting of the virgin white pine forests required a way to get the logs to market. As a result, many streams were used for this purpose. River banks were destroyed, streams were straightened for better log management and large amounts of erosion were the result. During this time period, water flow was also a source of power, resulting in dams being built to harness the water power. Many of these dams are past their useful life and should be removed. Industrial plants were naturally built adjacent to these power dams, bringing a variety of waste liquids and materials (some toxic) to the watershed of our streams. So, over 100 years ago much of the forests in the Great Lakes region were removed, steams dammed for power and a rise in industrial facilities occurred, all of which impacted the presence of clean, cold water suitable for trout.

Deforestation has many significant ecological consequences. The removal of vegetation results in increased erosion of soil sediments, which frequently deposited in water bodies, consequently depositing soil particles and nutrients. A decrease in vegetation also corresponds with a decrease in nutrient uptake in the soil, resulting in an increased rate of nutrient leaching from the soil. The leached nutrients are often deposited in water bodies. Both types of nutrient inputs subsequently alter physical stream characteristics as well as rates of productivity and ecological components of water bodies affected by deforestation.

Deforestation has a significant impact on stream phosphorus and silica concentrations. Both nutrients are geologically derived and are deposited in the stream via erosion. Therefore, increases in both phosphate and silica concentrations in deforested watersheds are strong indicators of the anthropogenic impacts that deforestation causes.

LEGACY ISSUES (cont.)

DAMS AND AQUATIC ORGANISM BARRIERS

Changes to ecosystems above and below a dam or barrier can be attributed to many factors. Sediment transfer, temperature variability, species richness, and overall habitat functionality are some of the effects dams and barriers have on river and stream systems. Increased deposition of sediments near the dam or barrier allows for more to be deposited in the gaps between the cobbles, altering habitat for macroinvertebrate and fish species. Temperature variations from potentially warmed water caused by a dam or barrier can create thermal obstacles. Due to this, reservoirs or obstacles created above dams and barriers can create changes in species type by physically altering habitat.

Dam and barrier removal are becoming more widespread as older dams and barriers are becoming increasingly eroded. Restored streams have been known to recover to pre-dam or pre-barrier conditions if given enough time.

URBANIZATION

Local climates can be influenced by urbanization – more people and their activities replacing forests and fields. The heat produced by these activities creates a microclimate for the area and often results in an increase in the surrounding temperature. This can be explained by heat given off by activities in the buildings, the hard structures that typically absorb heat from the sun and natural cooling from large trees and other vegetation being reduced. Also, the urbanization brings with it large areas of the land that get covered by surfaces that are impervious. So, when a rain event occurs, the rain water does not sink down through the soil to replenish the aquifer below but runs off into creeks and rivers. These rains events create high water flows in these streams, often significantly increasing the water temperature and erosion of the stream banks.

The Great Lakes watershed is home to three of the largest cities on the continent, as well as numerous medium sized cities. This spread of people creates many issues, including local sources of heat which adds to warming of the region, greater water use which reduces area water levels and lowers water stored in aquifers, requires more streets and roads that generate barriers to stream water flow and finally brings more hardened surfaces that deflect rain water from the soil.

LEGACY ISSUES (cont.)

URBANIZATION (cont.)

The increased population also results in a large quantity of waste products, particularly the waste generated years ago and buried in landfills which are now creating problems with toxic leaks into the ground water. The population centers were also home to many industries that, in years past, mishandled their waste products and discharged into our streams and lakes harmful chemicals such as mercury, PCB, oils, heavy metals, etc.

NUCLEAR WASTE

Introduction: According to an article published by the International Joint Commission (IJC), a total of 38 nuclear reactors at 16 commercial nuclear power stations have generated electricity in the Great Lakes basin. Today, there are 30 operating reactors at 12 commercial operations. Nuclear power production around the Great Lakes Region may be on the wane, but the IJC is studying the potential hazards created by the decommissioning of the existing nuclear power plants and will complete its study in 2020. Paramount to this study is the significant public concern about nuclear power, waste and storage.

Details: More than 60,000 tons of spent nuclear fuel is stored on the shores of four of the five Great Lakes. 50,000 tons is stored on the Canadian side as Canada has a larger nuclear power generation industry than the United States. This stock pile of spent fuel is growing in volume as each operating nuclear plant replaces approximately one third of its fuel each year. Much of this nuclear waste is stored in spent fuel pools within the power plant buildings and an increasing amount is now being moved to on site dry storage. The spent fuel assemblies must stay in wet storage for a minimum of five years before being allowed to be transferred to dry storage containers.

All the nuclear fuel that has ever been used to generate power is still stored on site because neither the United States or Canada have been able to put together a plan to transport this waste to a safe storage site. Most of this nuclear waste is stored very close to the lake shore, especially that which is in wet storage. This nuclear waste is extremely radioactive and will remain so for thousands of years.
The proximity of this radioactive waste to several major Great Lakes population centers is a high-risk situation that requires a solution.

Photo from: Great Lakes United

CONCLUSION

The Great Lakes are the largest clean, coldwater resource in the United States and represent 21% of the freshwater available in the world. Their boundaries contain 10 salmonid species of fish and many other sought-after game fish, providing abundant recreational and employment opportunities for millions of people. About 30% of TU's membership and 60 million Americans and Canadians are in the contiguous area of the Great Lakes. The Great Lakes region also provides tens of billions of dollars of economic income to the surrounding area. The future of the Great Lakes today is in turmoil and there is a great opportunity to reshape their future. Therefore, given the mission of Trout Unlimited to conserve, protect and restore North America's coldwater fisheries, the Great Lakes must be a major priority for TU as an organization.

How can Trout Unlimited support the restructuring process? Trout Unlimited is a major and well recognized player in the field of environmental science and conservation and it brings to the table an apolitical, science based, and sensible consortium of information and opinions to help guide the long-term planning needed to correct the many issues affecting the Great Lakes. In other words, TU needs to develop strategies to address the outlined issues to protect the future composition and restoration of the Great Lakes and continue to be actively involved in decision-making processes. Additionally, Trout Unlimited must leverage its tremendous advocacy potential to implement scientifically sound solutions and prevent adverse impacts on our natural resources.

Certainly, this is a lofty goal, but it is incumbent on all of us, as individuals, as an environmental organization, as conservation foundations and as an environmentally responsible nation to protect the water quality of the Great Lakes. Trout Unlimited, with its many chapters and councils, has the opportunity and the resources to make a difference. Through thoughtful and positive efforts, we can help to make that difference and start getting the many perils threatening the Great Lakes resolved.

TU NATIONAL LEADERSHIP COUNCIL GREAT LAKES WORKGROUP MEMBERS

Chair,
Robb Smith, *Michigan*

ILLINOIS
Ed Michael
Jerry Sapp
Greg Prosen
Walter Bock

IOWA
Jim Kelehan

MICHIGAN
Al Woody
Bryan Burroughs
Greg Walz
Robb Smith
Tom Mundt
Tom Quail
Michael Sipkoski

MINNESOTA
John Lenczewski
Stephen Carlton
John Hunt

NEW YORK
Chuck Godfrey
Scott Seidman

OHIO
Chris Steffen
Donald Dean
Jim Augustine

PENNSYLVANIA
Joe Greco

WISCONSIN
Linn Beck
John Rennpferd
Kim McCarthy

TU Staff Contact:
Taylor Ridderbusch
tridderbusch@tu.org
(715) 313-0001

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Trout Unlimited,
National Office
1777 N. Kent Street,
Suite 100
Arlington, VA 22209

TOLL FREE:
[800] 834.2419

Fax:
[703] 284.9400

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