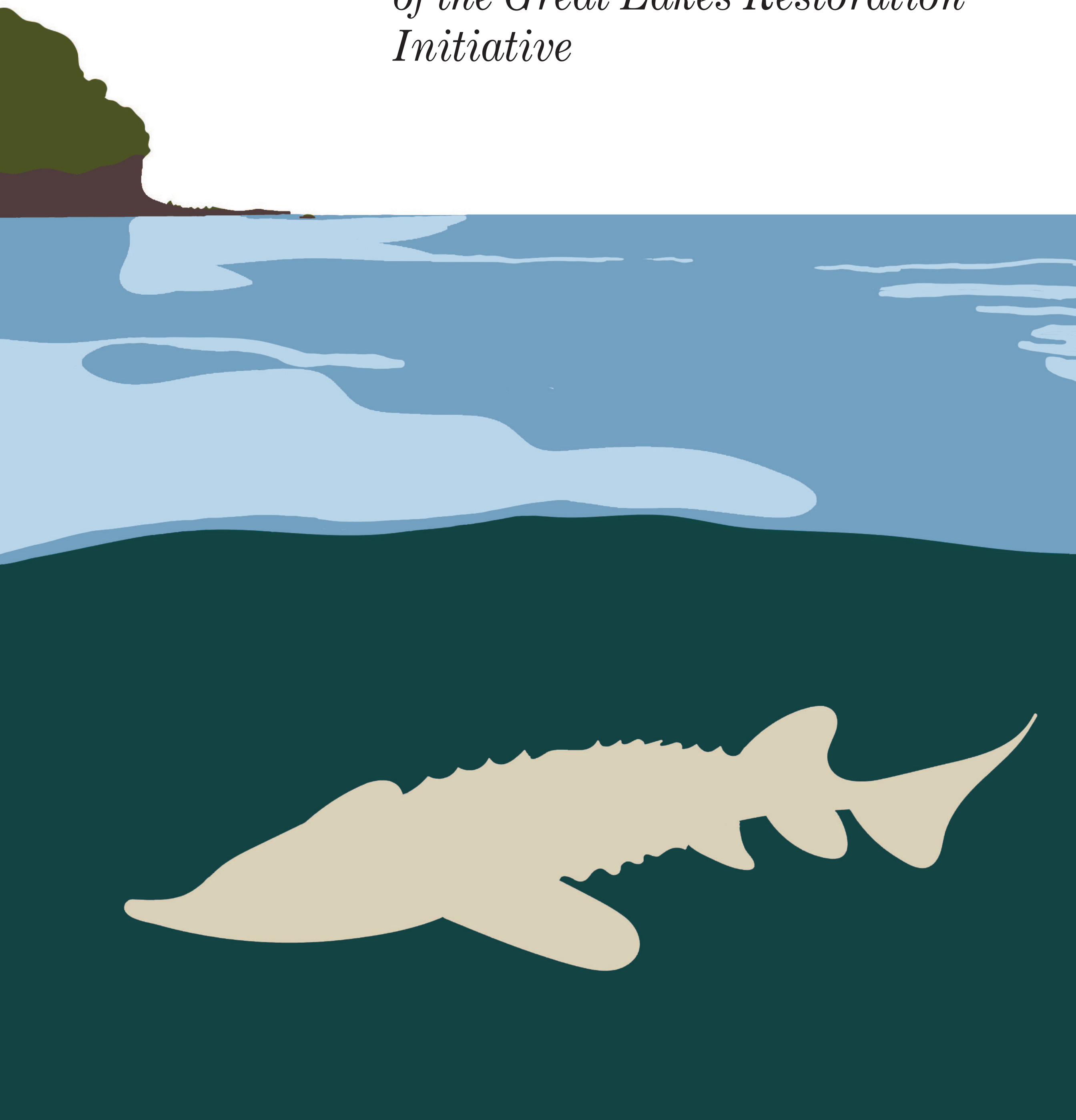
Restoring the Great Lakes

Success stories from a decade of the Great Lakes Restoration Initiative



Welcome

The sheer scale of the world's largest chain of freshwater lakes often startles first-time visitors of the Great Lakes. When standing on the shores of Lake Superior, Lake Huron, Lake Michigan, Lake Ontario or Lake Erie it quickly becomes evident how this tremendous resource earned its mighty title. Together the Great Lakes comprise more than 10,000 miles of coastline and 30,000 islands. They help us transport commercial goods, they provide jobs and help us generate power to heat our homes. They are a financial engine, injecting roughly $62 billion in American wages into the region.

The Great Lakes also nurture our spirits. They give us outstanding recreational opportunities to fish, boat, hunt, camp and so much more. We at the U.S. Fish and Wildlife Service work with partners across state, tribal and international boundaries to restore the Great Lakes for the fish, wildlife, plants and people that call this region home. We are also dedicated to collaborating with our partners in industry and non-profit organizations to find innovative solutions to recover threatened and endangered species, and even better, keep them off the endangered species list in the first place.

Please join us as we mark a decade of the Great Lakes Restoration Initiative with this retrospective collection of successes. We are proud of the passion that the women and men of the U.S. Fish and Wildlife Service bring every day to restoring the Great Lakes, especially over the past decade. We would like to thank all of our partners who have been vitally important in this huge undertaking. Throughout the last decade, more than a dozen federal agencies have implemented the Great Lakes Restoration Initiative. Generous support from countless academic institutions, state, tribal and nonprofit project partners furthered our actions.

Our projects in the Great Lakes reflect the passion and the hard work of our staff. We invite you to come witness that dedication for yourself. Come visit our national wildlife refuges and national fish hatcheries to learn more about the work we do and the people who make it happen.

Charlie Wooley
Regional Director
Interior Great Lakes Region

Wendi Weber
Regional Director
Interior North Atlantic-Appalachian Region

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Great Lakes Restoration Initiative

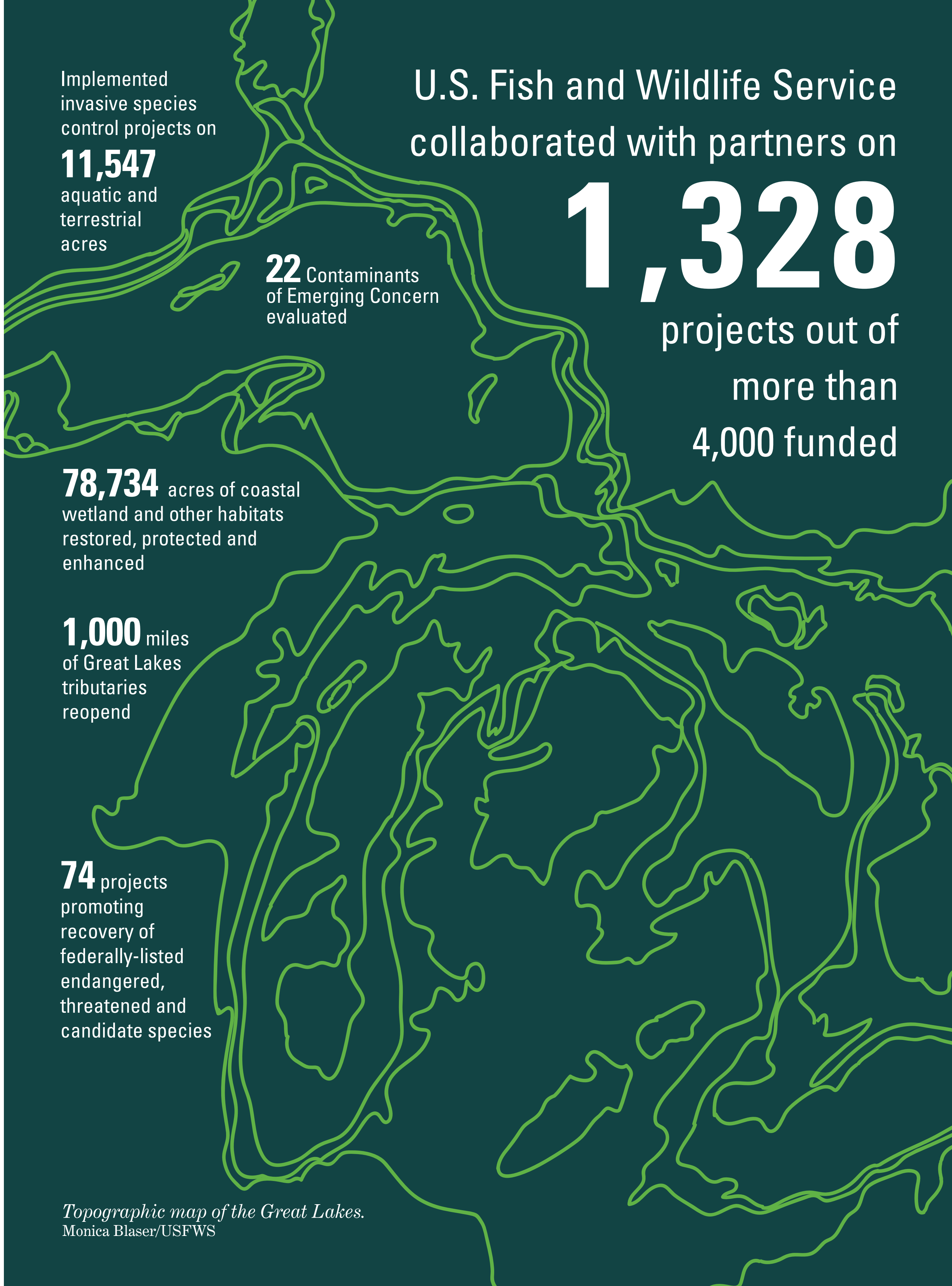
In celebration of a decade of the Great Lakes Restoration Initiative, we at the U.S. Fish and Wildlife Service are sharing a snapshot of our accomplishments in restoring and protecting this globally important freshwater system. This collaborative endeavor started in 2010, led by the U.S. Environmental Protection Agency and 15 other federal agencies, including U.S. Fish and Wildlife Service, with the goal to address the most significant environmental concerns of the Great Lakes. Over the last decade, we have been working side by side with partners to protect, restore and maintain the Great Lakes ecosystem. This work has focused on four main topics:

Toxic substances and areas of concern
Years after pollution stops, persistent pollutants can remain in the environment, often trapped in sediments below the surface of the water. We identified 43 areas within the Great Lakes Basin that were of special concern given past contamination and set out to restore and protect those aquatic ecosystems from the threat of persistent pollutants. During this time, we initiated projects that also address the looming threat of emerging contaminants like hand sanitizers, pharmaceuticals and other personal care products.

Invasive species
Back in 2010, more than 180 non-native species were considered established in the Great Lakes. The most invasive of these reproduce and spread so quickly that they out-compete native species. They ultimately degrade the habitat where they live and disrupt food webs.

Habitat protection and restoration
From climate change to increasing development activities along the shores of the Great Lakes, a multitude of threats are affecting the health of the Great Lakes habitats and native wildlife. Great Lakes Restoration Initiative funding has helped us to identify, restore and protect important habitat for native fish and wildlife.

Foundations for future restoration actions
The initiative has fueled climate resiliency through our efforts to educate the next generation about the importance of the Great Lakes to fish, wildlife, plants and people. Learn about some of the highlights of our science-based adaptive management approach for new and ongoing projects.



U.S. Fish and Wildlife Service collaborated with partners on **1,328** projects out of more than 4,000 funded

Implemented invasive species control projects on **11,547** aquatic and terrestrial acres

22 Contaminants of Emerging Concern evaluated

78,734 acres of coastal wetland and other habitats restored, protected and enhanced

1,000 miles of Great Lakes tributaries reopend

74 projects promoting recovery of federally-listed endangered, threatened and candidate species

Topographic map of the Great Lakes.
Monica Blaser/USFWS

Juvenile lake sturgeon. TJ Turner

Keeping our eye on the prize: Lake sturgeon recovery takes time

Release of lake sturgeon on the lower Niagara River. USFWS

Overfishing and pollution in the Great Lakes almost caused lake sturgeon to disappear 100 years ago. Barriers to migration blocked access to spawning habitats which further exacerbated sturgeon survival. The species remained somewhat of a mystery for decades, with many believing that they were completely gone, except for a few remnants surviving in Lake Superior. While seven of the eight states in the Great Lakes Region currently list lake sturgeon as either threatened or endangered, the future's looking brighter thanks to an array of projects supported by the Great Lake Restoration Initiative that have provided lake sturgeon assistance at every stage of their life cycle.

Federal, tribal, state and academic partners from Minnesota to New York have been working together, and diving deep into sturgeon waters, to locate sturgeon populations and find the answers we need to help this ancient species recover. We are also removing barriers to their migration, restoring and protecting habitat, and where necessary, we are giving lake sturgeon populations a boost with the help of hatchery stocking programs.

Wild lake sturgeon by the numbers

Today, biologists are observing increasing numbers of lake sturgeon in many remnant populations across the Great Lakes. Over the past decade, we've steadily been capturing more sturgeon each year in the lower Niagara River, Lake Ontario and Lake Michigan, and have gathered evidence that sturgeon are spawning. The similar age of sturgeon across the lakes suggests sturgeon recovery is likely due to actions that took place many years ago, such as the Clean Water Act of 1972 and fishing closures on lake sturgeon. The United States side of the Niagara River Corridor, iconic for its world-renowned waterfalls and globally significant bird and fish populations, was recently designated as a Wetland of International Importance under the world's oldest environmental treaty, the Ramsar Convention, in part because of lake sturgeon populations located in the Corridor.

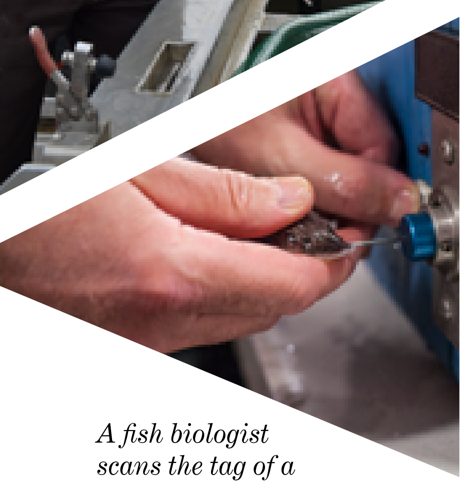
Catch rates of lake sturgeon in Lake Huron and Lake Erie have remained roughly the same for the past decade. However, we remain optimistic about sturgeon populations in these lakes. Lake sturgeon spawning occurs in eight tributaries to Lake Huron and stocking takes place in the Saginaw River watershed. In Lake Erie, spawning occurs in the St. Clair - Detroit River System, the body of water connecting Lake Huron and Lake Erie. Habitat restoration efforts in this system have created an additional six spawning locations over the last ten years. Additionally, during the spring of 2017, spawning was detected for the first time in Buffalo Harbor and lake sturgeon stocking in the Maumee River began in the fall of 2018. Still, lake sturgeon don't reproduce until they are 10 to 20 years of age. This means it will take at least 20 years to observe the impacts of our recovery efforts on recruitment and population growth.

Tracking sturgeon movements

Thanks to Great Lakes Restoration Initiative funding, we are gaining a better understanding of these ancient fish. With the aid of the Great Lakes Acoustic Telemetry Observation System we can track where they go and when. The system, established in 2010 by the Great Lakes Fishery Commission with Great Lakes Restoration Initiative funding, is a bi-national network of researchers collaboratively operating hundreds of stationary receivers and sharing data. The Lower Great Lakes Fish and Wildlife Conservation Office, Northeast Fishery Center and Alpena Fish and Wildlife Conservation Office have been working with partners to learn more about sturgeon in the lakes. They are tagging fish with acoustic tags in Lake Ontario, the lower Niagara River, Lake Erie, the Detroit and St. Clair Rivers and Lake Huron. Using telemetry, we determined patterns of lake sturgeon habitat use, which led to the creation of additional spawning habitat, as well as protection of critical areas. Additionally, it is helping us evaluate population demographics of lake sturgeon. Information gathered through telemetry

A fish biologist deploys an acoustic receiver in the Maumee River. Acoustic receivers are placed throughout the Great Lakes as part of the Great Lakes Acoustic Telemetry Observation System. USFWS

A fish biologist inserting an acoustic transmitter in an adult lake sturgeon. USFWS



A fish biologist scans the tag of a juvenile sturgeon. USFWS

A juvenile lake sturgeon is tagged at Genoa National Fish Hatchery. TJ Turner

contributed to decisions about stocking locations for first ever lake sturgeon stocking events in the Maumee River and Saginaw River.

While we have evidence of sturgeon spawning in some rivers, we know very little about young lake sturgeon from the time they hatch until they reach adolescence at about 10 years of age. Our Alpena and Lower Great Lakes Fish and Wildlife Conservation Offices have been targeting survey methods for wild, young fish in the Niagara, Detroit and St. Clair Rivers to verify whether sturgeon are successfully reproducing. In 2019, our team at the Lower Great Lakes Fish and Wildlife Conservation Office and staff with the U.S. Geological Survey began studying survival, movement patterns and habitat use of hatchery-raised juvenile lake sturgeon using acoustic telemetry. These hatchery raised sturgeon were stocked into the Genesee River, a tributary to Lake Ontario, by the Oneida Hatchery in New York. This work will help inform future habitat and sturgeon restoration efforts.

Restoring spawning habitat and aquatic pathways

When lake sturgeon are ready to reproduce they ritualistically return to the same waterways where they were born. However, limited access to suitable spawning reef habitat due to barriers such as dams and culverts has persistently hindered population sizes. Fish passage projects and spawning reef enhancement projects are essential to their survival. Habitat enhancement projects in the Detroit and St. Clair Rivers have been especially helpful to the Lake Huron population.

We've been working collaboratively with our industry partners to strategically remove barriers to fish migration and open pathways to prime spawning habitat for lake sturgeon. The Menominee River Fish Passage Project in northern Wisconsin is a choice example of industry directly supporting wildlife restoration. Driven by strong partnerships, the project was partially funded by the Menominee and Park Mill Hydroelectric Dams and restored 2,000 acres of lake sturgeon habitat. The project completed in 2015 was one of the first and largest fish guidance and bypass structure facilities for sturgeon in the Great Lakes. North American Hydro operates the fish passage as part of their normal hydropower operations.

Menominee Dam in Wisconsin. USFWS

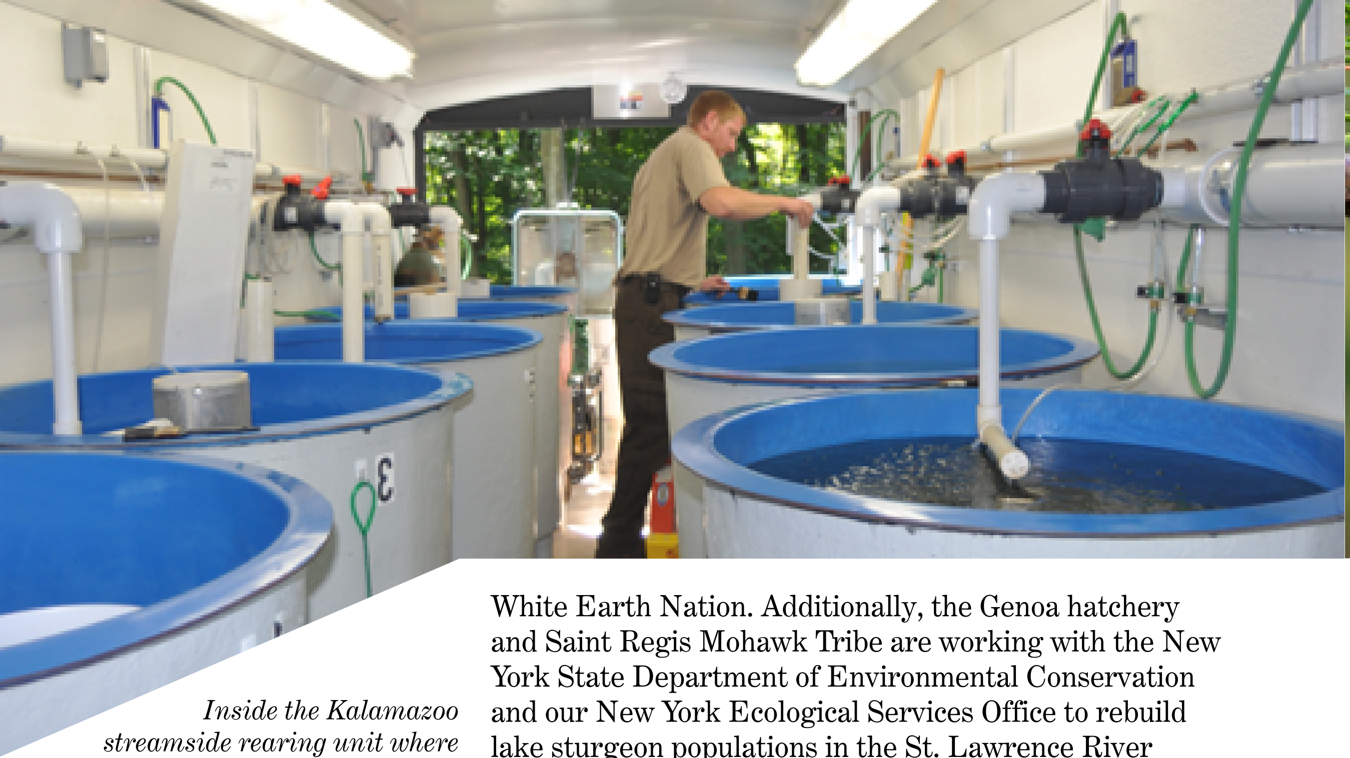
Working with tribal and state partners to raise and protect young sturgeon

Early Native American tribes revered the lake sturgeon as a cultural symbol and an essential staple. Within the clan system of early Native American tribes, the sturgeon represented a clan made up of educators, scholars and philosophers offering guidance to others. We collaborate with tribal partners to conserve, protect and restore this highly respected species.

We continue to work alongside tribal and state partners to operate streamside rearing facilities to boost larval survival. For almost a decade, trailers retrofitted to culture fish have helped protect young lake sturgeon during the early months of their life. The Gun Lake Tribe, in cooperation with the Genoa National Fish Hatchery, Green Bay Fish and Wildlife Conservation Office, Michigan Department of Natural Resources and the Kalamazoo River Chapter of Sturgeon for Tomorrow, have operated a small streamside sturgeon hatchery on the banks of the Kalamazoo River with Great Lakes Restoration Initiative funding. The Kalamazoo River unit is the sixth streamside facility on Lake Michigan supporting the recovery of lake sturgeon.

The Rainy River First Nation has been spawning lake sturgeon from the Rainy River along the Canada - United States border for stocking tribal waters. The eggs are shipped to the Genoa National Fish Hatchery where they are raised to fingerlings. Young sturgeon are then stocked into waters on the Red Lake Indian Reservation and the

Fish biologists using a portable ultrasound unit to determine the sex of an adult lake sturgeon captured in the St. Clair - Detroit River System. USFWS



Inside the Kalamazoo streamside rearing unit where young lake sturgeon are raised. Katie Steiger-Meister/USFWS

White Earth Nation. Additionally, the Genoa hatchery and Saint Regis Mohawk Tribe are working with the New York State Department of Environmental Conservation and our New York Ecological Services Office to rebuild lake sturgeon populations in the St. Lawrence River watershed using wild sturgeon from the St. Lawrence River.

Protecting lake sturgeon is more than restoring access to habitat and boosting spawning numbers. Since 2010, a contaminants team of biologists has investigated the occurrence of Contaminants of Emerging Concern to assess impacts to fish and wildlife across the Great Lakes Basin. These chemicals come from things like pharmaceuticals, personal care products, insect repellents and industrial and agricultural chemicals. In 2016, this team of biologists coordinated an analysis of contaminants in adult lake sturgeon blood serum and gametes. Contaminants were found in adult sturgeon serum, eggs and milt. These results were a cause for concern because the chemicals could be impacting lake sturgeon growth patterns and behavior. We began studying young lake sturgeon reared in streamside facilities in 2017, to better understand the effect of contaminants on rearing success, as well as their ability to imprint on natal waters.

From tracking migration patterns and habitat use of both adults and young lake sturgeon to researching the chemicals that impact them, we have learned a great deal about the species. Perhaps the greatest lesson we are learning from lake sturgeon is that recovery takes time.

Fish biologists collect samples from lake sturgeon for anaylsis. USFWS

Kirtland's warbler. Nathan Cooper/Smithsonian Migratory Bird Center

Designing a future for Kirtland's warblers

Future generations of Great Lakes visitors will continue to hear the soft trill of Kirtland's warblers thanks to the instrumental support of the Great Lakes Restoration Initiative. The Kirtland's warbler, a small yellow songbird that breeds almost exclusively in the Great Lakes Basin, hovered on the edge of extinction in 1974 when only 167 mating pairs remained in the wild. For more than two decades, the future of the Kirtland's warbler continued to be uncertain. The Great Lakes Restoration Initiative infused Kirtland's warbler conservation efforts with the resources needed to secure its steady climb toward recovery. In 2019, we gathered with partners to proudly announce the full recovery of the species and remove it from the endangered species list.

Great Lakes Restoration Initiative funding allowed managers and scientists to develop plans and improved management techniques to sustain the species and to support delisting. The Kirtland's warbler is often characterized as a conservation reliant species, meaning that without continued conservation efforts it would again become imperiled. In addition to helping solve the difficult problem of sustaining needed management for the species, the initiative funded breeding habitat restoration, as well as educational and community engagement efforts.

The need for active management

The primary threats to the Kirtland's warblers were the unique parenting style of brown-headed cowbirds and a decrease in breeding habitat of jack pine forest. Wildfires are the most important factor for creating dense stands of young jack pine that these songbirds need for breeding

A volunteer planting jack pine. Abigail Ertel/Huron Pines habitat. The heat from fire opens jack pine cones releasing the seeds and regenerating the forest. Modern wildfire suppression greatly diminished the natural disturbance that historically generated Kirtland's warbler breeding habitat. In the absence of wildfire, land managers had to take an active role in mimicking natural processes that regularly occurred within the jack pine ecosystem. This was primarily done through large-scale timber harvesting and human-assisted reforestation.

Brown-headed cowbirds lay their eggs in nests of other bird species, an act known as nest parasitism. Host parents unwittingly raise young cowbirds, which usually outcompete the host species' young. Brown-headed cowbirds are not native to this jack pine ecosystem and so Kirtland's warblers are especially vulnerable to nest parasitism. From 1972 to 2017, cowbirds were trapped and removed from Kirtland's warbler breeding habitat, reducing parasitism rates.

Blood is collected for analysis. Bill Rapai/Kirtland's Warbler Alliance

Geolocator with leg loops. Dan Elbert/USFWS

An extra helping hand

From 2010 to 2012, Great Lakes Restoration Initiative funded a term biologist to map out a plan to recovery for the Kirtland's warbler. This biologist assisted with a comprehensive species status review that served both as five-year review under the U.S. Endangered Species Act and a foundation for the development of the Kirtland's Warbler Breeding Range Conservation Plan. Completed in 2015, this conservation plan now guides the management strategy for the species. Additionally, the biologist developed a handbook for brown-headed cowbird management, which helped in transitioning the cowbird management program to the U.S. Department of Agriculture Animal and Plant Health Inspection Service for future management by their Wildlife Services program.

Recovering the Kirtland's warbler was a group effort. In partnership with the Upper Mississippi River/Great Lakes Region Joint Venture, Great Lakes Restoration Initiative supported the Kirtland's Warbler Habitat Management and Community Stewardship Project with the Huron Pines Resource Conservation and Development Council. This project provided a means for the Kirtland Warbler Conservation Team to develop GIS-based spatial planning tools to target habitat management, to bring more than 30 public and private partners together to identify opportunities for conservation, to develop educational

Building a cowbird trap. Chris Mensing/USFWS

and outreach tools for partners and to advance technical assistance for private landowners. Outcomes from this project include more than 2 million jack pine seedlings planted on nearly 1,500 acres of Michigan public lands and jack pine ecosystem management on private lands via forest management plans, timber harvest, plantings and prescribed burns.

In addition to Great Lakes Restoration Initiative funding, the Great Lakes Fish and Wildlife Restoration Act grant program supported two Kirtland's warbler projects that were essential to this conservation success. Restoring habitat for the federally endangered Kirtland's warbler by the Michigan Department of Natural Resources. This project regenerated approximately 2,000 acres of habitat through experiments with a mix of jack pine and red pine plantings to improve options for regenerating the young jack pines needed by Kirtland's warbler.

The grant funds also were key in developing a cowbird monitoring strategy to protect Kirtland's warblers under a reduced trapping program by the Smithsonian Institute. Approaches for managing cowbirds were developed using automated recording units and point-counts to assess cowbird and Kirtland's warbler abundance, monitoring for cowbird parasitism and developing population models.

Extracting a Kirtland's warbler from a mist next. Dan Elbert/USFWS

We would also like to recognize our private landowner partners and our colleagues in the U.S. Forest Service and the U.S. Geological Survey for their continued dedication to species recovery. Because of this collaboration, this species is thriving thanks to decades of effort by a diverse group of dedicated partners.

Lake trout. USFWS

Supporting lake trout across the Great Lakes

The Great Lakes recreational fishery is worth more than $7 billion annually and supports more than 75,000 jobs. Anglers come from all over the globe for quality fishing experience, including angling for the largest apex predator to the Great Lakes - lake trout.

Overfishing followed by loss of spawning reefs, parasitism by invasive sea lamprey and a B12 deficiency from a diet of alewife contributed to the basinwide collapse of the lake trout fishery by the 1950s. Since then, we at the U.S. Fish and Wildlife Service, along with our federal, tribal, provincial and state partners, have helped to save unique heritage strains of lake trout from vanishing. An international, intergovernmental and tribal collaboration of researchers and managers is successfully restoring this valuable recreational fishery all thanks to Great Lakes Restoration Initiative support.

Release of tagged lake trout. USFWS

Harvest regulations, sea lamprey control and hatchery stocking programs, funded in part through the Great Lakes Restoration Initiative, have collectively helped to restore lake trout populations. Lake Superior experienced 50 years of lake trout stocking beginning in the early 1950s and ending in the early 2000s as wild lake trout abundance significantly increased. Lake trout restoration in Lake Superior shows how our combined efforts can restore populations. Stocking in Lake Huron has recently decreased by roughly 67% due to the development of self-sustaining population of wild lake trout. We're also seeing positive signs in Lake Michigan and Lake Ontario, with growing populations of naturally reproducing lake trout.

Since its inception, the Great Lakes Restoration Initiative has supported native lake trout restoration efforts in the Great Lakes. Our national fish hatcheries, fish and wildlife conservation offices and fish health centers have been working with federal, tribal, provincial and state resource agencies toward realizing self-sustaining populations of lake trout. This includes continuing to stock Lake Ontario, Lake Erie, parts of Lake Michigan and Lake Huron, as well as marking and tagging hatchery fish to help assess restoration progress.

Maintaining and stocking heritage lake trout strains

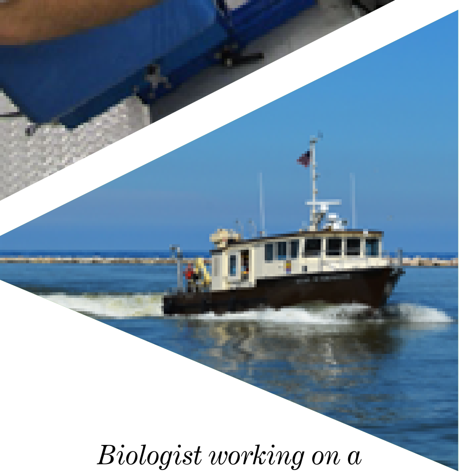
National fish hatcheries maintain five strains of lake trout from the Great Lakes Basin. Genoa National Fish Hatchery in Wisconsin is home to a modern quarantine facility for isolation of wild stocks that serves as a source of future brood fish held at other federal fish hatcheries. Wild eggs are brought to the facility where water is filtered and ultraviolet treated to prevent transfer of wild diseases. Fish must clear three disease tests before they are transferred to one of our adult holding hatcheries including Iron River, Sullivans Creek, Berkshire and White River to be used as broodstock. These hatcheries in turn supply other national fish hatcheries including Jordan River, Pendills Creek, Iron River, Dwight D. Eisenhower and Allegheny with genetically diverse strains of lake trout eggs to meet restoration objectives. In total, more than 3.5 million trout are stocked into Lake Michigan, Lake Huron, Lake Erie and Lake Ontario every year by national fish hatcheries including Iron River, Jordan River, Pendills Creek, Allegheny and Dwight D. Eisenhower, with stocking numbers fluctuating annually in response to management needs in the Great Lakes.

Monitoring lake trout in the field

Lake trout are wanderers, traveling many miles throughout the lake in search of food and habitat. Some even return to the same spawning areas each year. For the past eight years, the Lower Great Lakes Fish and Wildlife Conservation Office in New York has used Great Lakes Restoration Initiative funding to study lake trout as they travel from Lake Ontario to the Niagara River to spawn. U.S. Fish and Wildlife Service biologists are able to track trout for years using acoustic tags to learn more about this spawning behavior and the health of the population. We are finding that lake trout are naturally reproducing on their own in the Niagara River. Another key detail in these studies is that we are able to note the types of habitats that are essential to lake trout growth and reproduction which informs us of what helps them maintain a healthy population.

Taking inventory of fingerling lake trout at Iron River National Fish Hatchery. Mallory Mackey/USFWS

Lake trout eyed eggs at Pendills Creek National Fish Hatchery. Julie Timmer/USFWS



Biologist working on a fish processing line in a mass marking trailer. USFWS

Research vessel Stanford H. Smith arrives at its home port in Kewaunee, Wisconsin. Tim Patronski/USFWS

The Ashland, Alpena and Green Bay Fish and Wildlife Conservation Offices in Michigan and Wisconsin are also monitoring lake trout in Lakes Superior, Michigan and Huron to inform population management strategies, stocking decisions and develop actions to improve and maintain quality habitats in these lakes. Deployed in 2019, the research vessel Stanford H. Smith is helping to increase our scientific monitoring and research capabilities, with the mission of expanding assessments of fish communities in Lakes Superior, Michigan and Huron.

Great Lakes Restoration Initiative funding continues to be critical to our Great Lakes Mass Marking Program out of the Green Bay Fish and Wildlife Conservation Office. This comprehensive program tags and marks fish raised at U.S. Fish and Wildlife Service and state hatcheries in order to monitor predator-prey fish communities. Federal, tribal and state fishery managers use this information to restore native species, control invasive non-native alewife and evaluate habitat use.

Restoring lake trout habitat

The Great Lakes Restoration Initiative continues to support implementation of the Great Lakes Fish and Wildlife Restoration Act, the primary federal program dedicated to restoring important fish and wildlife and the habitat they depend on in the Great Lakes. The Act also enables the Great Lakes states, federally recognized tribes and private interests to implement practical solutions collaboratively to restore and conserve the region's fish and wildlife resources. Over the last decade, Great Lakes Fish and Wildlife Restoration Act grants funded projects aimed at the detection of lake trout reproductions in southern Lake Michigan and understanding lake trout distribution and spawning habitat occupancy in Lake Erie.

Through strategic habitat and research work, we have answered important conservation questions that have enhanced populations of threatened and endangered species and other native aquatic and terrestrial species within the Great Lakes Basin. These efforts will help achieve self-sustaining aquatic populations and contribute to acres and miles of habitat protected, restored or enhanced.

All of these efforts, with support from the Great Lakes Restoration Initiative, continue to be critical in sustaining current lake trout restoration successes.

Rebuilding the food web: How restoring native prey species could help lake trout in the Great Lakes

Fish biologists collect eggs from female bloaters.
Katie Steiger-Meister/USFWS

Bloater and cisco, sometimes referred to as lake herring, play critical roles in the food web of the Great Lakes, as prey for top predatory fish like lake trout and salmon. The native prey food base declined substantially, however, in all of the Great Lakes by the 1950s due to overfishing.

Re-establishing populations of bloater and cisco to the Great Lakes will increase the diversity of available prey species and increase prey fish production in the mid and deep water portions of the lakes. This is gaining interest from resource managers particularly in Lake Huron and Lake Ontario. The Great Lakes Restoration Initiative is helping support a cooperative, international effort between the Great Lakes states, Ontario Ministry of Natural Resources and Forestry, U.S. Fish and Wildlife Service, U.S. Geological Survey and Great Lakes Fishery Commission to restore these species in Lake Ontario and to support an experimental stocking program in Lake Huron.

Work to restore bloater and cisco is just beginning. Biologists are locating and evaluating remnant populations of bloater and cisco, collecting wild gametes and developing brood stock to supply fertilized eggs to hatcheries to assist with restoration activities.

Since 2017, the Northeast Fishery Center has stocked out over 555,000 cisco yearlings to re-establish the native forage fish in Lake Ontario. In November 2019, approximately 752,000 eggs were spawned. Following fish health clearance, these offspring will be stocked in Lake Ontario in 2020 or 2021. Additionally, Allegheny National Fish Hatchery began receiving fertilized bloater eggs in 2017 from wild adults collected in Lake Ontario by the White Lake Fish Culture Station in Ontario, Canada. In 2019, Allegheny stocked 4,750 juvenile bloater in Lake Ontario.

Propagation and stocking of cisco began at the Jordan River National Fish Hatchery in 2018. Fish were developed from wild northern Lake Huron stocks. To date, a total of 1.8 million cisco have been stocked into Saginaw Bay in Lake Huron. This work represented the first time this species has been cultured within the national fish hatchery system and is part of a 10-year reintroduction study.

Piping plover.
Jim Hudgins/USFWS

Piping plovers: A decade of progress

One of the hallmarks of the Great Lakes Restoration Initiative is the restoration and protection of habitat to support native species. Nowhere is that more important than in recovering endangered species. The imperiled plants and wildlife of the Great Lakes ecosystem are direct beneficiaries of Great Lakes Restoration Initiative support. One of the most iconic is the endangered Great Lakes piping plover, and GLRI funding has helped bring this shorebird back to places like Wilderness State Park in Michigan and Wisconsin's newly restored Cat Island chain in Green Bay.

A biologist sets up a trail camera to monitor a nest. USFWS

Nesting habitat is the key

The Great Lakes population of piping plovers once nested along the shores of all five Great Lakes, but by 1986, when the population was listed as endangered, piping plovers could be found nesting only on Lake Michigan. These small shorebirds rely on expansive areas of loose sand and gravel for nesting, but their ground nests are vulnerable to numerous predators as well as recreationists and changes in water levels. Their numbers dropped to an alarming 17 pairs at the time of listing as resource managers strove to identify, restore and protect their beach nesting habitat. With the restoration initiative came opportunities to expand partnerships and build capacity as we, the U.S. Fish and Wildlife Service, worked along with others to prevent extinction of this iconic shorebird.

The presence of suitable nesting habitat is key for piping plover recovery, as is protection of nests and chicks along beaches also popular for recreation and development. Together with our colleagues at the National Park Service, the state of Michigan and other partners, we were able to dedicate Great Lakes Restoration Initiative and other funding to locate and monitor nests, erect enclosures around the nest and raise awareness among beach-goers of the presence of endangered plovers. At the same time, efforts continued to restore and protect beach habitat used by Great Lakes piping plovers for nesting and rearing chicks.

Partners make a difference

All of this collective hard work paid off at sites like Wilderness State Park at the northern tip of Michigan's Lower Peninsula. The park's Waugoshance Point once supported nesting plovers, but plovers failed to return to the park to nest after 2006. Low lake levels and invading vegetation on the beach eliminated nesting opportunities for plovers.

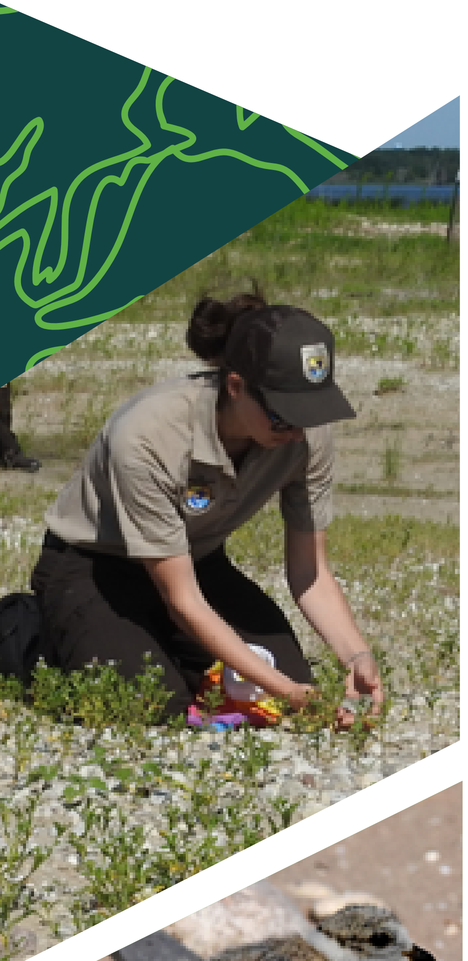
In 2012, we began a project with the Michigan Department of Natural Resources and the U.S. Geological Survey to restore plover habitat at three areas along Waugoshance Point. This entailed redistributing sand and cobble and removing plants and trees with the goal of creating better nesting habitat. The project was a success, and in 2016, a pair of piping plovers nested at the site and successfully fledged chicks. The birds have continued to return through 2019 and work is underway to evaluate the effectiveness of the effort.

The building of an island

While the majority of piping plovers can be found along shorelines in Michigan, plovers are also finding nesting opportunities in Wisconsin, thanks to partners working under the Great Lakes Restoration Initiative and other programs. A notable effort is the reconstruction of a chain of islands in Lower Green Bay. The Cat Island Chain is located in Lake Michigan's Green Bay and was once a vibrant habitat for an abundance of aquatic species, including fish, waterfowl and shorebirds. The expansive emergent marshes once were dotted with numerous small islands, beaches and mud flats and boasted an extensive area of submerged aquatic plant beds. The Cat Islands were a major stopover point on the Lake Michigan shoreline flyway for a wide variety of birds. They also served as an important Green Bay/Lake Michigan fishery.

However, historic water level fluctuations in the 1970s dramatically changed the islands and that had a ripple effect. Water levels rose rapidly to record highs and

Habitat for water birds and other wildlife as part of the Cat Island restoration effort.
Gary Van Vreede/USFWS



Piping plover chick release. USFWS

A banded piping plover chick. *Joel Trick*/USFWS

remained elevated for 20 years. Repeated severe spring storms took their toll, especially when rip-rap on shorelines deflected wave energy and intensified ongoing erosion problems. The islands literally disappeared. In addition, poor water clarity from runoff pollution reduced aquatic vegetation and their wave dampening benefits.

Fortunately, a host of partners stepped up to the plate to rebuild the 272-acre Cat Islands Chain. When Great Lakes Restoration Initiative funds became available in 2010 and began contributing to the restoration effort, other funding sources like a Fox River Natural Resource Damage Assessment grant, Wisconsin Harbor Assistance Program and the Port of Green Bay were augmented. The Cat Islands restoration project is a partnership among the Port of Green Bay, Brown County, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, Wisconsin Departments of Transportation and Natural Resources, Lower Fox River/Green Bay Natural Resources Trustee Council, University of Wisconsin Sea-Grant, University of Wisconsin-Green Bay and 14 Port terminal operators that began almost two decades ago and continues today. We assisted with habitat management by creating an expansive sandy beach with small rock cobble and young cottonwood trees - precisely the habitat preferred by nesting piping plovers.

The plovers return

With fewer than 75 nesting pairs of piping plovers in the entire Great Lakes population, island and backwater habitat is crucial to their recovery. As soon as the partners began to restore habitat, wildlife found it. An incredible diversity of fish and wildlife species use this area now, including several threatened and endangered species like the piping plover. Piping plovers were observed using Cat Island during spring and fall migration routes as soon as the project was built, and in 2016, piping plovers nested on Cat Islands, the first plovers to nest in Lower Green Bay in 75 years. Since then, nesting on Cat Island has occurred every season.

With contributions from efforts at sites like Wilderness State Park and Cat Island, Great Lakes piping plover numbers now top 70 pairs. Piping plovers have also started to return to historic breeding locations, and in 2017, they were recorded nesting on all five of the Great Lakes for the first time since 1955.

A monarch butterfly sits on native climbing fumitory on St. Martin Island.
Tina Shaw/USFWS

Growing local pride and protection for pollinators

Pollinators are a key part of the Great Lakes ecosystem and play a critical role in supporting plant communities which serve as food and shelter for wild animals such as pheasant, turkey and waterfowl. Land use changes have resulted in habitat fragmentation for many pollinators and the use of pesticides has impacted essential food sources pollinators rely on to survive. A changing climate is also altering food availability for pollinators at varying life stages. With these challenges in mind, the Great Lakes Restoration Initiative Pollinator Task Force was formed in 2018 and brought together biologists, GIS specialists and habitat managers from the U.S. Fish and Wildlife Service, National Park Service, U.S. Forest Service, U.S. Geological Survey and Natural Resources Conservation Service to focus our energy on the conservation of pollinators.

The team's vision began with the aim of creating a landscape that hosts self-sustaining native insect populations and will continue on into the next decade with a five-year conservation strategy that will increase pollinator resiliency, reduce the future need to list native insect pollinator species under the Endangered Species Act, restore pollinator habitat and increase general knowledge about their conservation in the Great Lakes. Looking farther back into the last decade, we've had other conservation successes that were all made possible with Great Lakes Restoration Initiative funds.

Growing habitat for pollinators

Thanks to the collaborative work of our partners, we have restored more than 4,500 acres of pollinator habitat over the last decade. While this collaboration through the U.S. Fish and Wildlife Service Partners for Fish and Wildlife Program is a long-running conservation success story across the country, our concentrated work in the Great

Local Girl Scouts plant a pollinator garden at Silo City in Buffalo, New York. USFWS

Karner blue butterfly.
Joel Trick/USFWS

Lakes has been bolstered by the strategic use of initiative funding.

Pollinator conservation is really about everyday people making positive change. By working with local landowners and other partners to voluntarily restore pollinator habitat on private lands, we have been improving habitat for threatened and endangered species like the Karner blue butterfly, Mitchell's satyr butterfly, Poweshiek skipperling and Pitcher's thistle. This restoration effort has several stages, starting with biologists identifying what habitat communities will improve conditions for maximum benefit of pollinators. The team then maps out a prescription for how to recover those habitats with treatments that can vary from hand pulling and cutting invasive plants, to using controlled fire and herbicide in localized treatments, all with the goal of making room for these fragile species to regain their footing in the landscape. The next step is to add native nectar plants and larval host plants back to these recovering areas. Pollinator nurseries like this can happen anywhere - from rural to suburban and urban geographies - we work with partners who promote pollinators and provide foraging habitat for migratory birds and other wildlife across the Great Lakes.

Since 2011, the Chicago Park District has been growing a sense of community through pollinator gardens with assistance of Great Lakes Restoration Initiative funds. Thanks to these efforts, Park 562, an undeveloped property on Chicago's far southeast side, now provides resting, foraging and nesting grounds for hundreds of pollinator species. Horner Park, one of Chicago's largest parks on the north side, restored a 10-acre parcel of underutilized park and riverbank. Now, 600,000 citizens within three miles of the site have access to restored habitat and shoreline. In 2014, Montrose Point Bird Sanctuary and later in 2015, Northerly Island Park, bolstered pollinator habitat which increased the size and biodiversity of these highly visited educational and recreational green spaces along the Lake Michigan shoreline.

Chicago is one of many cities working to bring pollinators to urban backyards. At a historic site called Silo City, along the Buffalo River Area of Concern in Buffalo, New York, community members planted a native garden along the riverfront after removing the invasive Japanese knotweed

Students from Tapestry Charter School and McKinley High School plant native plants at Silo City in downtown Buffalo, New York.
Betsy Trometer/USFWS

in 2016. It takes a whole community of dedicated people, including volunteers and students, to make restoration efforts like this stick. Local Girl Scout troops expanded the garden further upland between the river and Lake Erie. We are pleased to see people from all walks of life reclaiming green spaces for pollinators and other wildlife and find that engaging at the local level fosters a deeper understanding of what a healthy habitat should look like, cultivates environmental awareness and develops connections to outdoor spaces. Most importantly, people grow pride in their local landscape.

In addition to restoring private land and underutilized public spaces, we also put Great Lakes Restoration Initiative funding into protecting delicate island ecosystems. In 2015, we worked with The Nature Conservancy to expand Green Bay National Wildlife Refuge to include most of St. Martin Island and all of Rocky Island in Lake Michigan, adding another 1,290 acres to the 330-acre refuge. The islands are part of the Grand Traverse chain, which extends from Wisconsin's Door Peninsula to Michigan's Garden Peninsula. These island gems provide important stopover habitat for migratory birds and other animals throughout the Great Lakes each spring and fall. Ornithologists, botanists and other researchers from around the world come to these remote islands to study the diverse plant life that has persisted here for millennia. Many of these plants depend on pollinators to continue their life cycle. One particular pollinator, the monarch butterfly, uses these islands as stepping stones during their long migration to overwintering grounds in central Mexico. They drink nectar, rest and sometimes seek shelter from storms on these coastal habitats. Expanding the refuge system to include these islands is an incredible achievement.

Poweshiek skipperling butterfly.
Vince Cavalieri/USFWS

A biologist collects an eaglet as part of the eagle monitoring program. Kim LeBlanc

Gauging eagle health in Michigan

We at the U.S. Fish and Wildlife Service are a key partner in addressing impaired wildlife populations and health at several contaminated hot spots around the Great Lakes, designated as Areas of Concern. The industrial past of the Great Lakes deposited chemical compounds called polychlorinated biphenyls or PCBs, dioxins and other legacy contaminants in the waters and in turn the fish of these areas. These contaminants gradually accumulated in fish-eating birds like bald eagles and herring gulls, causing developmental deformities, reproductive problems and ultimately contribute to population declines. The Great Lakes Restoration Initiative has supported major contamination cleanups and habitat restoration as well as post-remediation monitoring. To understand if contaminant levels are safe for wildlife, we collaborated with the state of Michigan and universities to evaluate the health and reproduction of these iconic birds.

Volunteers collect eaglet data before it is returned to its nest. Kim LeBlanc

Collaborating with the Michigan Department of Environment, Great Lakes and Energy, formerly known as Michigan Department of Environmental Quality, we have utilized an existing, long-term statewide bald eagle reproduction and contaminants monitoring program to study wildlife deformities and reproductive problems at four Areas of Concern in the Saginaw River and Bay, River Raisin and the Detroit and Kalamazoo Rivers. This program began during the time when bald eagles were federally endangered, in part due to eggshell thinning associated with DDT, and has continued throughout population recovery.

Bald eagles were removed from the Federal List of Endangered and Threatened Wildlife in 2007. Since 2014, the Great Lakes Restoration Initiative has supported the reproduction and contaminants monitoring effort. Airplane flights over these areas detected new eagle nests, as well as successful reproduction. When chicks were present on the nesting sites, we collected blood samples for contaminant analysis. Currently, bald eagles are producing at least one chick per nest in three of the four Areas of Concern, which suggests that the cleanup and habitat restorations have benefited eagle populations. While this is good news, the chicks sampled have elevated contaminants that may harm them and negatively impact their reproductive success.

To give us a better understanding of the eagle's overall health in these areas, we look to other birds like herring gulls to gain a better understanding and gauge bird health on a population level in these specific geographies. Like bald eagles, herring gulls depend on these contaminated hotspots for feeding and nesting. For the last decade, Dr. Keith Grasman of Calvin University has provided this valuable research. With support from the U.S. Fish and Wildlife Service and Great Lakes Restoration Initiative, Grasman has studied the reproduction, health and contaminant levels in herring gull nesting colonies in two Michigan Areas of Concern in the Saginaw River and Bay and River Raisin. Studying large numbers of these fish-eating birds provides the data needed to examine deformity rates and assess bird health. His research has shown that since contaminant cleanups, PCB levels in eggs have decreased, however, they remain higher than what is considered healthy.

Understanding how the health and reproduction of these birds improves throughout the long process of recovery of these geographies is key to understanding the overall improvements in the ecosystem. Studying multiple species is crucial to show an accurate picture of ecosystem health and provides vital information about what areas still need improvement to eliminate wildlife impairments and ensure bald eagles continue to soar in the Great Lakes.

A biologist climbs to an eagle nest. Tim Kaufman

Bald eagle at six weeks of age. Jeremy N. Moore/USFWS

Electrofishing results in hundreds of Asian carp jumping out of the water.
USFWS

Taking back our waters

Originally imported from Southeast Asia to the southern United States in the 1970s as a biological control method for vegetation in man-made aquaculture ponds and wastewater treatment facilities, Asian carp escaped into America's rivers not long after. Flooding and accidental releases allowed these fish to escape into the Mississippi River system and migrate into the Missouri and Illinois Rivers. Because the Mississippi, Missouri and Illinois Rivers are all connected and fish swim freely between them, these escapes were not isolated. The Illinois River is also connected to the Great Lakes by a manmade connection, known as the Chicago Sanitary and Ship Canal. By the early 1990s, these invaders had taken hold and were threatening to continue their migration farther north to the Great Lakes.

A fish biologist weighs a bighead carp.
Ryan Hagerty/USFWS

While we have aimed to limit the population that already has a foothold in the southern reach of North America, we strategically began work to keep them out of the Great Lakes a decade ago, because we saw a grave environmental danger. If a self-sustaining population of Asian carp were to become established in the Great Lakes, it would hurt native fish populations and recreational opportunities alike. The four species of Asian carp found in the United States are all fast growing and prolific feeders that are able to out-compete native fish for food, as well as alter the underwater environment, rendering it is uninhabitable for other native plants and animals. Silver carp also jump out of the water when agitated by the sound of a boat motor, which poses a safety hazard to recreational boaters. Thus began our unified fight with the help of Great Lakes Restoration Initiative funds.

Stronger together

Our fight against these aquatic invaders is much like Aesop's fable of the bundle of sticks in that in unity comes strength. The past decade of collaboration across state and watershed boundaries has been vital due to the potential of Asian carp to disperse widely in open systems and negatively impact habitats on a landscape-level scale. As the Great Lakes Restoration Initiative was being formulated in 2009, we knew that fighting this fight alone, or even in parallel, would be a fruitless exercise. State governments, nonprofits and our fellow federal agencies, as well as tribal and international governments, have been vitally important in implementing management and control strategies on a national level. Our collective successes stand because of the commitment from state agencies to work together to develop approaches to manage these invasive fish.

The Asian Carp Regional Coordinating Committee was formally established in early 2010 and represents the collaborative efforts of international, federal, state and municipal agencies to combat the spread of Asian carp into the Great Lakes. Over the past decade, the committee has provided oversight and coordination of interagency prevention activities through an annual Asian Carp Action Plan and complementary Monitoring and Response Plan. This work was made possible by a shared sense of commitment felt by everyone involved. We continue to be united through our actions to protect the Great Lakes, and the waterways of the United States and Canada, from invasive Asian carp.

Asian carp are aggressive migrators and high water events on America's waterways only add to their ability to advance. Along with our partners on the Asian Carp Regional Coordinating Committee and under the leadership of the U.S. Army Corps of Engineers, we've been assessing and addressing hotspots across the Great Lakes and Upper Mississippi Basin through the Great Lakes and Mississippi River Interbasin Study. Across a nearly 1,500-mile divide that separates river runoff from the two basins, the 2010 study identified 18 geographic locations where Asian carp and other invasive species could spread through aquatic pathways. In the past decade we set out to improve these aquatic pathways of concern.

One of the most egregious of these locations is Eagle Marsh near Fort Wayne, Indiana. This 716-acre wetland lies between two rivers, the St. Mary's and the Wabash, on a continental divide for the Mississippi River Basin and Lake Erie. In 2010, after scientists discovered that Asian carp in the Wabash River could reach these waters, we set out to change the hydrology. In response, we worked with our partners to design

Atop the berm at Eagle Marsh, near Fort Wayne, Indiana.
Melissa Clark/USFWS

A biologist collects water samples from the Chicago Area Waterway for eDNA testing.
Monica Blaser/USFWS

a berm that's almost two miles-long to stop the Wabash River from mixing with the St. Mary's River and potentially on to Lake Erie.

Early monitoring

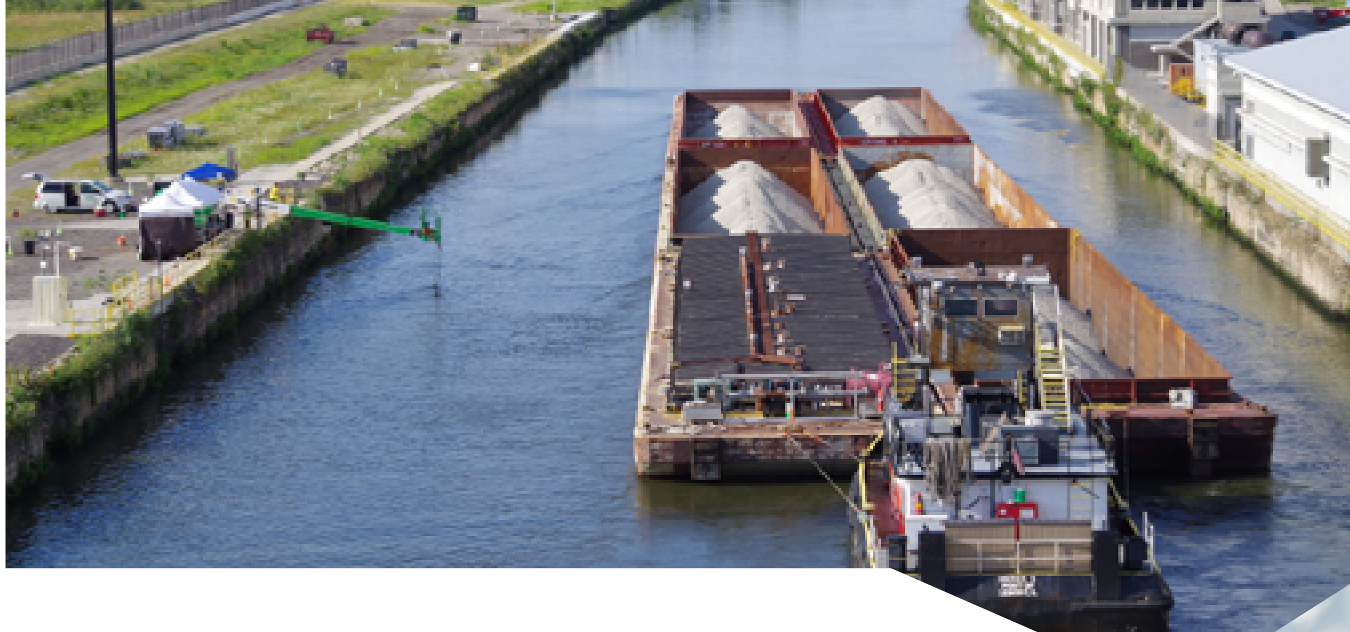
Invasive species are notorious for creeping into waterways undetected. Often, by the time the presence of an aquatic invader is known, the species is established in the environment and they are difficult to eradicate. Catching the early invaders is key to preventing invasive species from gaining a foothold in a lake or waterway.

With that in mind, we established the Whitney Genetics Lab in 2013 to fight the spread of water-borne disease and invasive species like Asian carp. This 5,800 square-foot, state-of-the-art research facility pushes the boundaries of genetic science. After only seven years in operation the lab has processed more than 47,000 samples. Using a technique known as environmental DNA, or eDNA, U.S. Fish and Wildlife Service staff are currently processing water samples taken from across the Great Lakes Region to detect the presence of Asian carp genetic material. Patterns of positive eDNA findings in waterways over time can give managers clues about where the leading edges of the Asian carp populations are located. In addition to eDNA monitoring, the lab is also developing other genetic tools to identify invasive species and are building a reference DNA sequence database to support this work.

In 2013, the first mobile eDNA laboratory hit the road across the midwest. Made possible with Great Lakes Restoration Initiative funds, and designed by the Alpena Fish and Wildlife Conservation Office, this custom-built, mobile lab was first utilized in the Chicago Waterway System to determine the presence or absence of Asian carp eDNA. This self-contained lab allows our biologists to prepare samples near targeted collection sites, which not only reduces the expense associated with sampling, but also the time it takes to respond to positive findings. Since mobile testing began, we have used this technology to screen more than 33,000 water samples from small tributaries to the greatest of lakes, including Lake Superior, Michigan, Erie and Huron.

Holding the line

America's roads, rails and rivers are major commercial routes for transporting goods across North America. In the 20 year span from 1994 to 2014 the Brandon Road Lock and Dam, about 27 river-miles southwest of Chicago on the Illinois River, had an average of 13.2 million tons of commercial goods moved through annually. Unfortunately these key transportation



A barge tow utilized during the 2016 barge studies.
USFWS

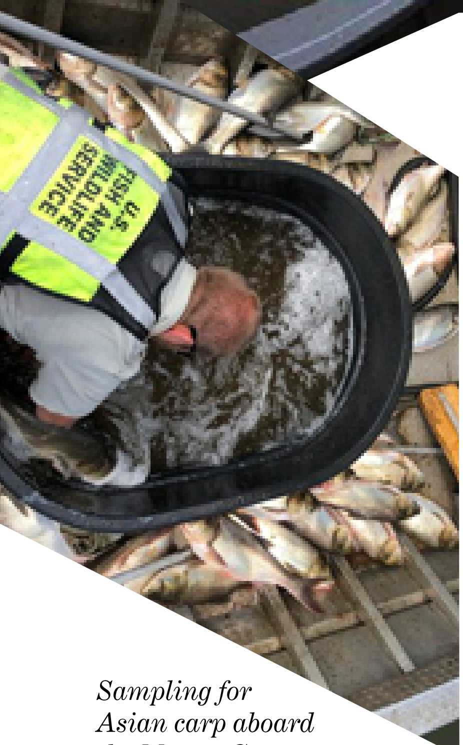
networks are also convenient conduits for invasive species, including Asian carp.

With this in mind, the U.S. Army Corps of Engineers built a series of electric dispersal barriers and other deterrents to slow the well-established Asian carp population in the lower three pools of the Illinois Waterway from moving north and getting closer to the confluence of Lake Michigan. Additionally, U.S. Fish and Wildlife Service crews spend more than 10,000 hours a year, monitoring and surveying the Illinois River in this same fight.

In 2012, the Carterville Fish and Wildlife Conservation Office team set out on their first of six barge studies, with the objective of determining if there was a potential for commercial barge traffic to facilitate fish passage beyond the electric dispersal barriers located within the Chicago Sanitary and Ship Canal. The short answer is, yes.

In 2015, in cooperation with the U.S. Army Corps of Engineers and the U.S. Geological Survey, we completed a barge study which indicated that small free-swimming fish can become inadvertently trapped between barges and transported for substantial distances. In 2016, this interdisciplinary group conducted additional studies. These study results showed that it is possible for barges moving downstream, away from Lake Michigan, to temporarily cause a decrease in the electric charge in the canal and cause water in the canal to reverse direction and flow upstream, toward Lake Michigan. The takeaway is that these combined effects could increase the risk of small fish being able to move upstream through the electric barriers we have in place to restrict Asian carp migration.

Biologists pack processed eDNA samples for transport outside a mobile lab.
Monica Blaser/USFWS



Sampling for Asian carp aboard the Magna Carpa. USFWS

A fish biologist seperates Asian carp from native species after electrofishing on the Illinois River. Wes Bouska/USFWS

We continued to conduct studies in 2017 and 2018 to investigate mitigation efforts to stop or reduce the occurrence of reverse flow and drops in voltage. After countless hours in the field studying barge traffic, fluid mechanics and the effectiveness of the electrical barriers, we are now able to inform the work of our partners in the development of solutions. U.S. Army Corps of Engineers has proposed further studies in 2021 in which we would provide support. Great Lakes Restoration funding allowed the Carterville team to identify and explore a previously unknown vulnerability to the Great Lakes Asian carp defense system. We continue to keep our eye on the prize and stay focused on keeping Asian carp out of the Great Lakes.

A great example of this is our ongoing successes on the Missouri River. In 2014, our Columbia Fish and Wildlife Conservation Office team in Missouri designed and launched the Magna Carpa, a special vessel that detects and removes all sizes of silver carp from the water. Building off of ocean system technology, staff modified a net originally designed to catch jumping white shrimp. Known as a Paupier net, it moves on winches in and out of the water like wings and fishes the surface of the water down to a depth of 10 feet. Used in conjunction with electric fields created by two electrified curtains of wire cables, the system stuns the invasive fish and then scoops them up as they passively float into the nets. In the five years that the Magna Carpa has been in action, our team has captured more than 200 tons of Asian carp. Currently, the vessel is optimized to reliably remove seven tons a day - that's the equivalent weight of more than four automobiles!

Evidence of water quality issues can be seen following a significant rainfall event where the Lower Fox River meets Green Bay. Photodynamix

A collaborative effort to create a Blueprint for the Lower Fox River and Green Bay

You may be surprised to learn that Wisconsin is home to one of the largest freshwater estuaries in the world. An estuary is an area where a river meets a larger body of water, usually a sea or ocean. These areas serve as natural filters for runoff and provide suitable nursery habitat for wildlife, including fish and birds. The estuary where the Lower Fox River meets Green Bay, and in turn Lake Michigan, is no exception. The area is the historic home to a great diversity of fish and wildlife including lake sturgeon and piping plover and provides tremendous benefits to humans and wildlife alike.

The Lower Fox River and Green Bay estuary has been impacted by a history of degradation from chemical compounds such as polychlorinated biphenyls, or PCBs, used in paints, plastics and dyes, other contaminants, overfishing, industrialization and urbanization. One of the largest challenges faced today is poor water quality due to the introduction of excessive amounts of phosphorous, sediments and nutrients into the system. Given the value of the Fox River and Green Bay system to plants, wildlife and local communities, municipal, state, federal, tribal and non-governmental organizations are dedicated to tackling these challenges to create a resilient, sustainable and economically thriving system. The size and scope of such challenges are too great to tackle alone.

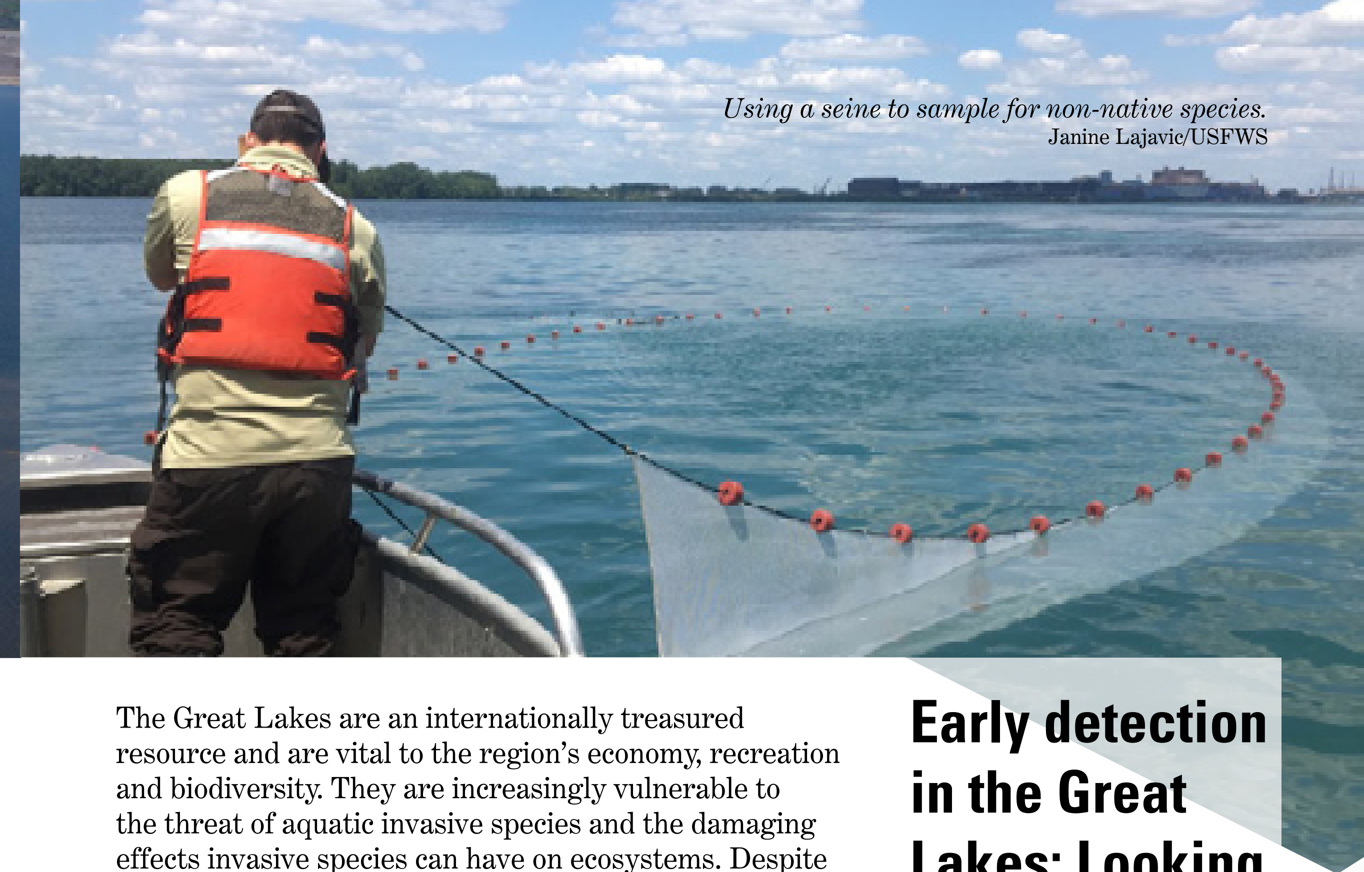
Working together, partners have initiated a landscape conservation design approach to address the scale and complexity of the issues impacting the estuary and are maximizing their ability to enact meaningful,

Juvenile lake sturgeon. USFWS

A wave barrier constructed along Cat Island shoal in lower Green Bay to protect wetland habitat. USACE

Piping plover. Jim Hudgins/USFWS

positive change. What has emerged is the Green Bay Conservation Partners' Landscape Blueprint. The Green Bay Conservation Partners' Landscape Blueprint seeks to coordinate conservation and inform decision-makers in directing conservation dollars to achieve shared goals within the Green Bay region. Since 2016, the blueprint process has been bringing together different voices to develop shared goals and values for this system. More than 50 different diverse conservation organizations from throughout the watersheds are contributing to the development of the conservation blueprint. The products from the process include maps, tools, social science reports and an implementation plan with strategies designed to maximize conservation work in both the short term and long term. From this landscape conservation design approach, the partners will promote a thriving, resilient landscape into the future. Partners will use the associated Blueprint Implementation Plan as a guiding document for strategic conservation work within the system to connect with decision-makers and potential funding partners. Gaps and needs will also be identified for future focused work.



Using a seine to sample for non-native species. Janine Lajavic/USFWS

Early detection in the Great Lakes: Looking for the needle in the haystack

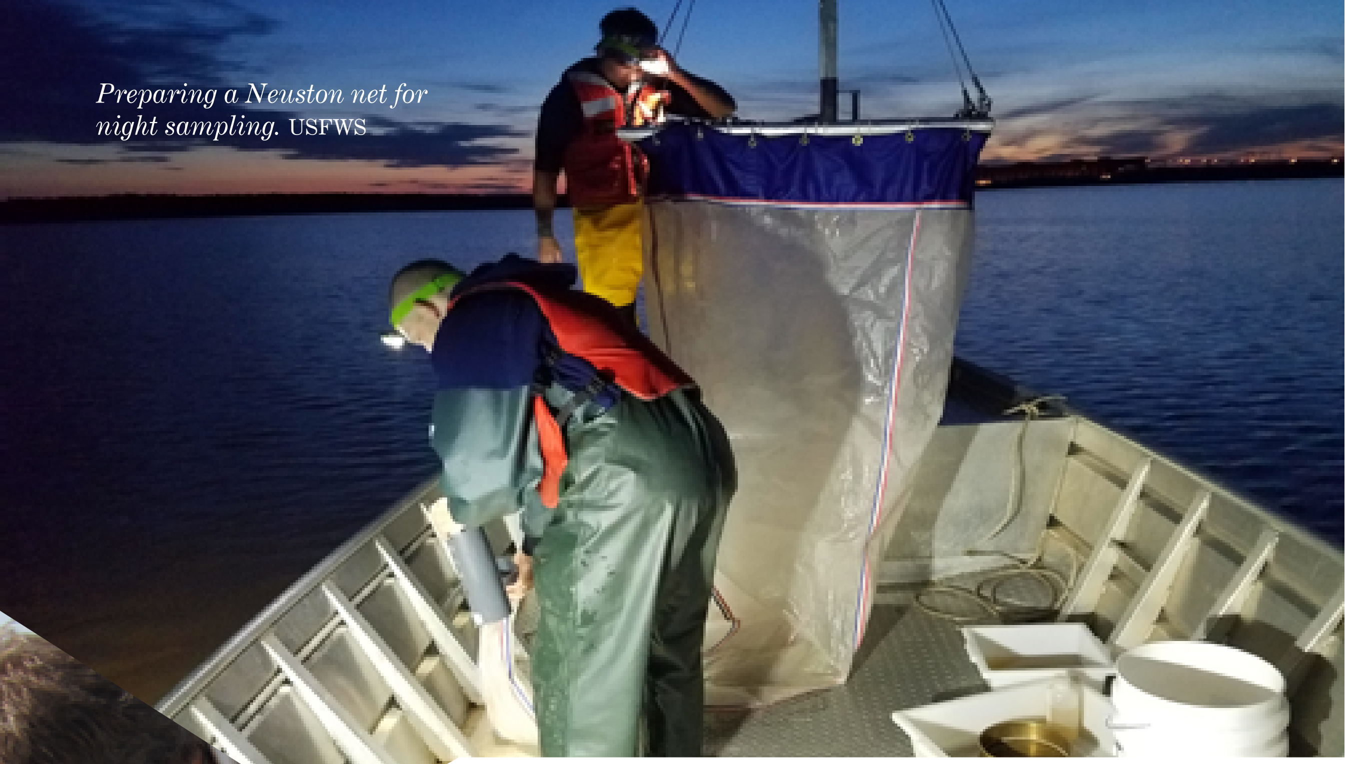
The Great Lakes are an internationally treasured resource and are vital to the region's economy, recreation and biodiversity. They are increasingly vulnerable to the threat of aquatic invasive species and the damaging effects invasive species can have on ecosystems. Despite increasing regulations aimed at reducing the likelihood of the introduction and spread of aquatic invasives into the Great Lakes, there remains a need to monitor for and detect new species while they are still small and localized. Early detection is the second line of defense, after prevention, which can equip natural resource management agencies with the tools and information to respond rapidly to new invaders.

Since 2010, we at the U.S. Fish and Wildlife Service have implemented a comprehensive Great Lakes Early Detection and Monitoring Program under the Great Lakes Restoration Initiative to conduct sustained, basin wide surveillance for high risk non-native species. Fish and Wildlife Conservation Offices from Ashland, Wisconsin to Buffalo, New York, are working across jurisdictions in collaboration with other federal, tribal, state and local partners to build coordination capacity and improve the efficiency of detecting new invasive species.

Where and how: Hot spots and sampling gears

We along with partners developed a Strategic Framework for the Early Detection and Monitoring of Non-Native

Inspecting a fyke net. USFWS



Preparing a Neuston net for night sampling. USFWS

A biologist measures a fish as part of sampling. USFWS

Fishes and Select Benthic Macroinvertebrates to guide field efforts and outline a sampling protocol for the program. The framework was used to develop lake-specific implementation plans in which high risk invasion areas, or hot spot locations, were identified for targeted sampling based on risk assessments of transport mechanisms, pathways, and potential suitability for non-native species.

Within each hot spot location we conduct assessments on fish at multiple life stages including larval, juvenile and adult, as well as macroinvertebrate assessments using a suite of sampling gears. Traditional gears such as fyke and gill nets, bottom trawls and electrofishing are used for juvenile and adult fishes, whereas light traps, benthic sleds and dip nets are used for larval fishes and macroinvertebrates. Genomic techniques, including the use of next generation sequencing and environmental DNA, are also being developed and tested as tools to increase both the efficiency and accuracy of specimen identification.

Gears are selected to maximize capture of potential non-native invasive species that are identified through ecological risk screening summaries we conduct. Many of these potential invaders are considered watch list species by federal and state partners and are identified as likely to be introduced and likely to pose a threat to Great Lakes natural resources.

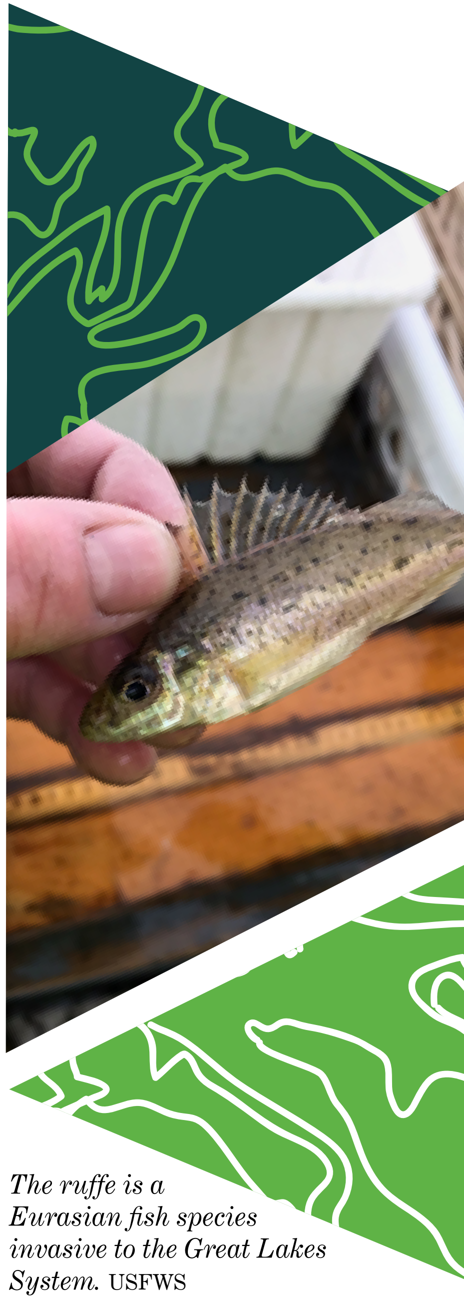
What have we found?

Since 2010, this comprehensive surveillance program has accomplished an impressive level of sampling effort throughout the Great Lakes with a cumulative effort of 11,863 sampling events across the basin. These sampling events resulted in no new non-native species detections. The program has observed range expansion of several non-native species that currently exist in the basin, including ruffe, tubenose goby, white bass, faucet snail and most recently, bloody red shrimp. In each case, findings were communicated promptly to resource managers and partners in the basin so that an appropriate response could be evaluated and implemented in a timely manner.

Each finding of a non-native species in a new location is important because it informs resource managers about changes in the ecosystem and potential impacts to aquatic habitat and more complex food web structures. However, significance of a finding varies based on the relative risk of a species and the documented history of invasiveness in other parts of its range. For example, the collection of a single bloody red shrimp in Lake Superior in 2017 was considered a more significant finding because it was screened as a potentially high-risk species for the Great Lakes and is a watchlist species for the State of Wisconsin.

Adaptive strategy

We are consistently learning new ways to be more effective and efficient with sampling as we continue to implement the Great Lakes Early Detection Program. Program biologists and managers convene annually to discuss accomplishments and lessons learned from the previous field season, while also incorporating adjustments in sampling methodologies for the upcoming year. Data is shared among Service offices and findings are summarized and reported annually to our partners in a collaborative effort to enhance the efficiency of the program and also the communication with resource managers and stakeholders.



The ruffe is a Eurasian fish species invasive to the Great Lakes System. USFWS

U.S. Fish & Wildlife Service
1 800/344 WILD
http://www.fws.gov

Great Lakes Region
http://midwest.fws.gov

North Atlantic-Appalachian Region
http://northeast.fws.gov

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