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GREAT LAKES BASIN REPORT©

Special Report – Great Lakes Regional News

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Highlights of the Annual Lake Committee Meetings

Great Lakes Fishery Commission proceedings, Ypsilanti, Michigan

This second of a series of annual special reports is an extensive summary of Great Lakes Region-wide activities. These lake committee reports are from the annual Lake Committee meetings hosted by the Great Lakes Fishery Commission in March 2019. We encourage reproduction with appropriate credit to the GLSFC and the agencies involved. Our thanks to the USFWS for their contributions to these science documents.. Thanks also to the Great Lakes Fishery Commission, its staff, Bob Lamb & Marc Gaden, for their efforts in again convening and hosting the Lake Committee meetings in Ypsilanti, MI.

Great Lakes Regional News

Index of Reports

Highlights

- USFWS raised and released 3,553,088 yearling lake trout for lakes Michigan, Huron, Erie, and Ontario
- 3.7 million Lake trout, 2.4 million Chinook salmon & 2.9 million steelhead were fin clipped in 2018 for lakes Michigan and Huron
- All Chinook salmon, lake trout, and steelhead were successfully clipped or tagged
- In Lake Huron, 65% of the lake trout captured during monitoring surveys were of wild origin
- 30% of lake trout recovered in Lake Michigan had no fin clip and were presumed wild
- In Lake Michigan, the highest proportion of wild fish (38%) was documented from Illinois
- During April-August 2018, 88% of the recovered Chinook salmon that were stocked in Lake Huron were captured in Lake Michigan at age 1
- Since 2011, all Chinook salmon stocked in Lake Michigan and the U.S. waters of Lake Huron received a coded wire tag and/or an adipose fin clip
- Since 2011, all Chinook salmon stocked in Lake Michigan and the U.S. waters of Lake Huron received a coded wire tag and/or an adipose fin clip
- Since 2010, all lake trout have been tagged/clipped at FWS hatcheries in Region 3 (Lakes Michigan and Huron)
- Since 2012 all lake trout at FWS hatcheries in Region 5 (Lakes Erie and Ontario) have been tagged and clipped
- Percent of ILL Chinook salmon during 2018 that were wild (without a fin clip or CWT - 70.1%
- Percent of IND Chinook salmon during 2018 that were wild (without a fin clip or CWT - 65.1
- Percent of Lake Michigan Chinook salmon during 2018 that were wild (without a fin clip or CWT - 67.1
- Percent of Lake Huron Chinook salmon during 2018 that were wild (without a fin clip or CWT - 68.2
- No live bighead or silver carp were found in any new locations immediately downstream of the electronic barrier

Abbreviation	**Expansion**
ADCWT	Adipose fin clip/coded wire tag
CLC	Council of Lake Committees
CPH	Catch per hectare
CPUE	Catch per unit effort
CWT	Coded Wire Tag
DEC	NY Dept. of Environment Conservation
DFO	Dept. of Fisheries and Oceans

MDNR	MI Dept. of Natural Resources
IL DNR	IL Dept. of Natural Resources
ODNR	Ohio Dept. of Natural Resources
OMNRF	ON Ministry of Natural Resources
USFWS	U.S. Fish and Wildlife Service
YAO	Age 1 and older
YOY	Young of the year (age 0)

Great Lakes Highlights 2018, FWS: Fish and Aquatic Conservation Program

Lake Trout Broodstock Management

To meet the stocking requests for the restoration of lake trout in each of the five Great Lakes, the U.S. Fish and Wildlife Service (Service) manages multiple broodstock hatcheries across the country; Iron River National Fish Hatchery (NFH), WI, Sullivan Creek NFH, Ml, Saratoga NFH, WY, Berkshire NFH, MA, and White River NFH, VT. Lake trout eggs for the spring of 2018 yearling stocking were produced from several distinct broodstock strains: Superior Klondike Reef (SKW), Lewis Lake (LLW), Seneca Lake (SLW), Huron Parry Sound (HPW), and Lake Champlain Domestic (CLD).

Lake Trout Production and Stocking

In 2018, the Service's Iron River, Jordan River, Pendills Creek, Allegheny, and Dwight D. Eisenhower NFHs raised and released 3,553,088 yearling lake trout into the Great Lakes in support of lake trout rehabilitation, and in accordance with Lake Committee rehabilitation plans and the 2000 Consent Decree. The M/V Spencer F. Baird delivered fish to four priority areas in Lake Huron and 18 priority areas in Lake Michigan. The vessel was underway for 49 days throughout the entire distribution season and traveled over 1,980 miles in the upper Great Lakes. Distribution for all the Great Lakes included 543,560yearlings into Lake Huron, 2,413,601 into Lake Michigan, 197,925 into Lake Erie, and 398,281 into Lake Ontario. All lake trout yearlings were adipose fin clipped and coded-wire tagged prior to stocking.

For 2019, the Service is preparing to stock approximately 3,500,000 yearling lake trout into the Great Lakes, all of which were adipose fin clipped and coded-wire tagged by the Great Lakes Mass Marking Program in 2018. The M/V Spencer F. Baird will continue to deliver lake trout yearlings offshore to prescribed rehabilitation sites in Lake Huron and Lake Michigan in 2019.

Lake Trout Post-stocking Assessment

Surveys conducted in 2018 by the Fish and Wildlife Conservation Offices (FWCO) in Green Bay and Alpena have documented continued progress toward lake trout restoration in lakes Michigan and Huron.

Egg Incubation Facilites at Iron River NFH

In Lake Huron, approximately 50% of the lake trout captured during monitoring surveys conducted by the Alpena FWCO in northern Lake Huron were of wild origin. Catch rates of wild lake trout have increased markedly since 2008 and continued recruitment of wild fish is evident in summer graded mesh surveys conducted by the Alpena FWCO since 2003. Long-term monitoring of spawning lake trout at offshore reefs (Yankee Reef and Six Fathom Bank) in Lake Huron began in 1994 and recent surveys suggest that more than ten year classes of wild fish are now contributing to the spawning stock at these historically important sites. Wild fish now compose a significant portion (>50%) of the offshore spawning population.

In Lake Michigan, most of the lake trout stocked since 2009 have been allocated to the Northern and Southern Refuge reef complexes. Increased stocking and a concomitant reduction in sea lamprey mortality have rapidly increased lake trout abundance in the Northern Refuge reef complex. Spring gill net assessments caught <1 lake trout per 1000' of net in 2009 but this has increased to >15 lake trout since 2016. This increasing trend is also evident at most survey locations in the northern half of Lake Michigan. The highest

2018 spring survey catch rates occurred within the Southern Refuge, 25 lake trout per 1000' net. Catch rates are much lower (<12 fish) at other surveyed areas in southern Lake Michigan. Lakewide, all sites except the Southern Refuge remain below the spring evaluation objective of 25 lake trout per 1000'; however, fall gill net assessments indicate adult spawner abundance exceeds 50 lake trout per 1000' at most of the reefs throughout Lake Michigan and suggests spawner abundance is sufficient to support natural reproduction. Detection of wild lake trout from assessment surveys has been stable throughout management units in the southern half of Lake Michigan. The highest proportion of wild fish (38%) was documented from gill net assessments in lllinois while wild fish from other southern and mid-latitude waters comprised 5 to 25% of lake trout catches. These southern waters have a diverse age structure among spawning populations; natural recruitment remains undetectable in the northern waters of Lake Michigan where current spawning populations are solely comprised of relatively young fish.

Lake Trout Research

ln 2018, the Green Bay FWCO began collaborations with state and Michigan State University scientists on developing a lake-wide model to estimate total standing stocks of lake trout in Lake Michigan and incorporating rates of exchange of fish among statistical districts by examining the recovery of coded wire tagged hatchery fish from sport and assessment fisheries. A manuscript that examined factors affecting survival of lake trout stocked at the primary stocking zones in Lake Michigan was developed by Green Bay FWCO and co-authored by state, federal and tribal biologists and was submitted for publication consideration. Lake trout diets in northeast Lake Michigan were described in collaboration with university of Michigan and USGS biologists and was also submitted for publication, and will augment on-going lake wide efforts by Service, MSU, and MIDNR biologists to update diets and eventually total prey consumption of lake trout and Pacific salmon in Lake Michigan. Green Bay FWC0 biologists participated as invited co-authors on two book chapters in an upcoming text on the complete biology and life history of lake trout in North America, and contributed another chapter on the Lake Superior lake trout recovery effort to a second text on fisheries management success stories throughout the world.

In 2018, the Ashland FWCO continued to work cooperatively with the National Park Service (NPS) to sample historic lake trout spawning sites around Isle Royale National Park. Isle Royale has been less impacted by the dramatic changes to the Lake Superior ecosystem and the NPS is interested in measuring the extent of remnant of lake trout diversity and habitat (bathymetry and substrate composition), at many historic lake trout spawning sites. Ultimately the data collected should aid the management and conservation of lake trout stocks near Isle Royale.

In 2018, the Lower Great Lakes FWCO continued a study using acoustic telemetry to track lake trout movements during spawning season in the lower Niagara River. This study is in cooperation with New York State Department of Environmental Conservation (NYSDEC), and leveraged GLRI funding with Natural Resource Damage Assessment funds. The study assesses the timing and cues associated with river spawning lake trout that use the Niagara Gorge habitats for spawning. A total of 20 fish were tagged in 2015 and 2016. Although no new tags were implanted in 2018, data collection in the river is on-going and will continue through spring 2019. Fine-scale tracking showed many movements that are believed to be associated with spawning and staging. Large-scale movements were observed as tagged fish moved around the lake and showed up on GLATOS receivers.

Upgraded Assessment Capability

A new 57' multipurpose vessel, the R/V Stanford H. Smith, will help increase the scientific monitoring and research capabilities for the Service's Upper Great Lakes FWCOs starting in 2019. Named for former Service biologist Stan ford Smith, who contributed seminal works on the ecology, distribution, and exploitation of Great Lakes ciscoes, this vessel's mission is to continue and expand assessments of fish communities in the Upper Great Lakes. The vessel, built by Moran Iron Works in Onaway, Ml, was sea-tested in

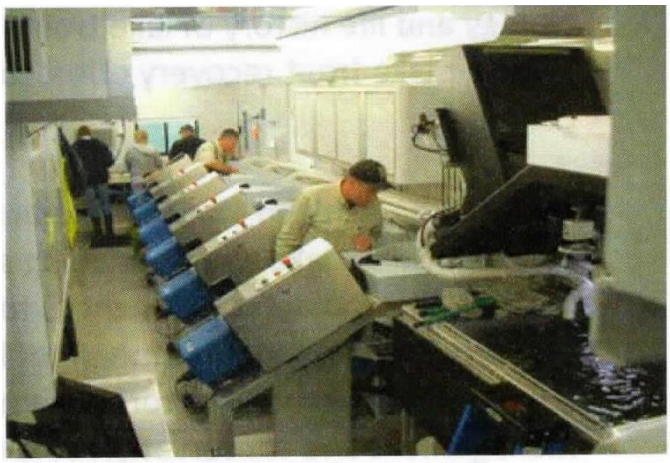
The new R/V Stanford H. Smith

October 2017 and was delivered to its home port of Kewaunee, Wisconsin in June of 2018. The vessel encountered some setbacks during its maiden summer in 2018, and was used minimally returning to dry dock a The R/V Stanford H. Smith number of times to remedy issues that were identified. With a cruising speed of 17 knots, the R/V/ Smith provides the FWCOs with a technologically advanced monitoring and research platform that can travel quickly and safely throughout Lakes Michigan, Huron, and Superior. The vessel is equipped with a gill net lifter, hydraulic winches, net reels, and net configuration sensors to deploy and retrieve gillnets, mid-water and bottom trawls, and 120 kHz split-beam transducers to measure fish biomass

with hydroacoustics. The R/V Smith emphasizes Region 3's commitment to science for the conservation of native species within the Upper Great Lakes.

Great Lakes Mass Marking

At the request of the Council of Lake Committees, the Service continued to deliver a Mass Marking Program in 2018, with the goal of marking/tagging all salmonines stocked into the U.S. waters of the Great Lakes. With $1.4 million in Great Lakes Restoration initiative funding, and carryover funds, the Program coded-wire tagged and/or fin-clipped 3.7 million Service-reared lake trout for lakes Michigan, Huron, Erie, and Ontario, as well as 2.4 million State-reared Chinook salmon, 2.9 million State-reared steelhead, and another 0.9 million fish of various species for lakes Michigan and Huron. A detailed report of Service tagging activities in 2018 is available upon request.



Operating parameters for the automated tagging trailer are optimized by our experts for each species of fish we tag

Twelve seasonal technicians assisted Wisconsin, Illinois, Indiana, and Michigan with tag recoveries on lakes Michigan and Huron in 2018. The lab collected data on over 13,350 sport-caught salmon and trout and recovered 14,595 tags from these and other fish from weir and assessment activities. Wild lake trout recoveries from the Lake Michigan sport fishery were highest in southern and western Lake Michigan (26 -50 %) than elsewhere (0 -18%), and lakewide percent wild increased from 16 -17 % in 2014 -2016 to 26% in 2017 and 30% in 2018. In Lake Huron, 65 % of sport caught lake trout were wild, continuing an increasing trend (50 -57 % in 2014 -2017). Results also indicated sustained natural reproduction of Chinook Salmon, as 68% of fish recovered from Lake Michigan and 68% from Lake Huron were of wild origin in 2018, consistent with values from the past several years. Technicians also collected tissue and stomach specimens from five salmon and trout predators to understand the changing Lake Michigan food web, tissues from lake trout and Chinook salmon to estimate non-lethal, physiological effects of sea lamprey attacks, and otoliths (ear bones) to determine stream-specific production of wild steelhead and Chinook salmon in Lake Michigan using microchemistry signatures.

Staff scientists continued to provide analytical support to states. Lab biologists contributed to a study published in the *North American Journal of Fisheries Management* that found Chinook salmon stocked in Lake Huron began to move into Lake Michigan to feed after collapse of alewife in Lake Huron in the mid-2000's. Chinook salmon survival and growth rate also tended to be highest for fish stocked on the western shore of Lake Michigan, and annual differences in Chinook salmon growth mirrored variability in year-and-older alewife density. Origin of Chinook salmon harvested by anglers in each jurisdiction, and recovery locations of Chinook salmon stocked in each jurisdiction, were determined and shared with state partners. Recoveries of lake trout with legacy coded-wire tags (1985-2003) showed that post release survival was lower for fish stocked in northern Lake Michigan than southern Lake Michigan,

likely due to differences in harvest and sea lamprey predation, and that survival was higher from Lake Michigan remnant genetic strains. Returns of mass-marked lake trout suggested offshore-stocked fish contributed more to recreational angler harvest than nearshore-stocked fish. Sea lamprey wounding rates from 2012 -2016 were also evaluated from salmon and trout species on lakes Michigan and Huron, and suggested that Chinook salmon are used by sea lamprey as alternate hosts to lake trout. Finally, lab scientists assisted with developing diet and ration estimates for the five primary salmon and trout species in Lake Michigan.

Fish are sorted by size and moved through an automated system within each trailer where they receive an adipose fin clip and a coded wire tag.

All species fed on alewife, but results highlighted spatial and seasonal variability in diets of lake trout, brown trout, and steelhead, which were more reliant on other prey such as round gobies and terrestrial invertebrates than Chinook salmon and coho salmon, which fed more exclusively on alewife. The findings are consistent with earlier and ongoing

work with stable isotope signatures which reflect long term diet and foraging location. These works, including the Chinook salmon inter-lake movement study, Chinook salmon growth study, lake trout survival study, and salmon and trout diet studies, are highlights from eight authored or co-authored studies submitted to or published in scientific journals by Mass Marking scientists during FY 2018.

In 2019, the mass marking program anticipates receiving $1.4 million in operational funds through the GLRI. These funds will be used to: tag and fin clip similar numbers of fish as last year; continue the recovery effort on lakes Michigan and Huron; and provide technical support related to all aspect of the tagging and marking program including cooperative analysis of the tag recovery data. A permanent addition to the Service base budget will be required to obtain remaining capital equipment and to provide operational funding needed to fully implement and sustain the Mass Marking Program across all the Great Lakes into the future.

Lake Sturgeon Streamside rearing

ln 2018, the Ashland, Alpena, and Green Bay FWCOs and the Genoa NFH continued to operate and provide technical assistance to streamside rearing facilities on the Ontonagon River in Lake Superior, the Kalamazoo River in Lake Michigan, and the Maumee River in Lake Erie. The intent of streamside rearing is to rear and stock juvenile lake sturgeon in a manner that promotes imprinting and site fidelity so that stocking can help build populations to self-sustaining levels while minimizing genetic risks to wild populations from potential straying.

The Ontonagon River facility is the only one operating on Lake Superior and is a partnership between the Service, Michigan DNR, Ottawa National Forest, Upper Peninsula Power Company, Fond du Lac Band, and Keweenaw Bay Indian Community. Using the Sturgeon River, MI as a source, eggs were collected from 3 females which were paired with 15 males (1:5 ratio). A total of 759 young-of-year (170 mm TL) lake sturgeon were PIT tagged and released into the Ontonagon River in September 2018, with surplus fish of varying sizes being released into the Ontonagon River Streamside Rearing Unit. upper St. Louis River, MN in support of the Fond du Lac Band's rehabilitation efforts. Since 2013, a total of 3,516 PIT tagged young-of-year lake sturgeon reared at the Ontonagon River streamside facility have been stocked in the Ontonagon River following approved and published guidelines designed to establish founding populations in rivers over a 25 year period.

The Kalamazoo River facility is one of six streamside facilities being operated across the Lake Michigan basin by a multi-agency partnership (to build and restore populations. Since 2004, over 40,000 fall fingerling lake sturgeon have been stocked from these facilities following approved and published guidelines designed to establish founding populations of 750 adults in each river over a 25 year period.

The Maumee River facility is operated by the Toledo Zoo with technical assistance from the Service. In the spring of 2018, gametes were collected from 9 female and 37 male lake sturgeon in the upper St. Clair River. Sturgeon were reared at the Genoa NFH in addition to the streamside rearing facility to evaluate survival, movement, and imprinting between the two stocking strategies. As a
Juvenile lake sturgeon result of the collections, 2,949 young of year (174 mm TL) lake sturgeon were released into the Maumee River, following the guidelines of the Maumee River Lake Sturgeon Restoration Plan. The Maumee River rearing facility is the only one operating on Lake Erie and the fall stocking event was the first in the Lake Erie basin. The Maumee River Lake Sturgeon Restoration Program is a partnership between the Ohio DNR, Ontario Ministry of Natural Resources and Forestry, Michigan DNR, Purdy Fisheries Ltd., Toledo Zoo & Aquarium, The U of Toledo, U of Windsor, USFWS, and USGS.

Assessments and Coordination

Lake sturgeon spring adult spawner and lake-wide juvenile assessments continued to be conducted by several of the FWCOs across the Great Lakes in coordination with partner agencies. Additionally, the Service conducted juvenile lake sturgeon assessments in the Detroit River and western Lake Erie to monitor the impact of constructed spawning reefs, worked with commercial fisherman in lakes Huron, Michigan, and Erie to report, sample, and tag additional lake sturgeon, and continued to maintain the Great Lakes lake sturgeon tag identification database and website.

Sturgeon passage on the Menominee River, Lake Michigan, continued in 2018 for a 4th year. Up and downstream passage facilities constructed in 2015 now allow movement of sturgeon around the first 2 dams on this river system. Facilities include an upstream elevator, sorting and holding tanks, a truck and transfer facility, and downstream protection and guidance racks leading to downstream bypass flumes. Operation and evaluation is conducted by a close partnership of biologists and researchers from the Michigan DNR, Wisconsin DNR, Eagle Creek Renewable Energy, UW-Stevens Point, River Alliance of Wisconsin and the USFWS. Objectives have been to pass approximately 30 mature females and 60 mature male sturgeon upstream each year during an initial 4 year evaluation period. Studies during this period have helped identify optimal operation times and attraction flows and have documented that 85% of the adult sturgeon passed upstream have quickly migrated 20 miles upstream and occupied high quality spawning habitat during the spawning season before moving back down river to Green Bay. Passage operations beginning in 2019 will attempt to increase passage of adults so that spawning numbers and reproduction upstream continues to increase.

A young- of-year lake sturgeon captured during bottom trawl assessments in the St. Clair River, Ml.

To assess rehabilitation stocking progress in the Ontonagon River, MI the Ashland FWCO works with partner agencies to conduct an annual standardized juvenile/sub-adult gill net survey. In 2018, catch per unit effort was 2.0 sturgeon/305 in net night, up from 0.9 sturgeon/305 in net night in 2016 and 2017. Stocked juvenile lake sturgeon begin to show up in gill nets two or three years after stocking and catch per unit effort is highly correlated with the number of juvenile lake sturgeon stocked 3 -50 years prior.

Ashland FWCO initiated a spawning run assessment to establish a baseline for the lake sturgeon population in the Ontonagon River in 2018. Stocking began in 1998 and there is potential for early maturing adults to return to spawn. Acoustic receivers were deployed throughout the river system and gill nets and set lines were used to capture spawning run fish. The field crew also visually inspected likely spawning habitat at Victoria Dam, and several other locations for the presence of spawning lake sturgeon. One fish was observed immediately downstream of Victoria Dam.

In 2018, the Lower Great Lakes FWCO continued its population assessment work in the lower Niagara River. Samples were collected from 114 new fish bringing the total count of unique fish sampled since 2010 to 1,109. During this period, there have been 90 recaptures for a re-capture rate of 8%. Although there is a robust adult population (estimated to be greater than 5,000 individuals), few fish under 10 years of age have been caught in the river, raising concerns about the populations future outlook. To investigate this possible gap in recruitment, the office conducted egg and larval surveys. For the first time, hundreds of viable eggs and drifting larvae were collected in the Niagara gorge. This demonstrates that the population is reproducing and that successful spawning is occurring in the gorge. Future research will focus on the juvenile population rather than continued adult assessment and discovering what habitats they may be using.

Recent surveys have shown that in Michigan's highly alkaline Manistee and Muskegon rivers, young lake sturgeon exposed to TFM during sea lamprey treatments can experience high mortality. In 2016 and 2017, the Service's Green Bay FWCO and Sea Lamprey Control Programs worked with the Little River Band of Ottawa Indians and Michigan DNR to collect and temporarily remove wild age-0 sturgeon from these rivers during the scheduled TFM treatment, and then return them to the river immediately after treatment. This work protected 117 Manistee River sturgeon in 2016 and 27 Muskegon River sturgeon in 2017. Post treatment surveys have verified the importance of this rescue effort in preserving sturgeon year classes in lamprey treatment years. This work will be conducted again on the Manistee and Muskegon rivers in 2019.

Acoustic Telemetry

The Service continued to lead or assist with ongoing telemetry studies in Lake Superior, the St. Clair - Detroit River system, the Maumee River, and in Green Bay tributaries and utilized portable ultrasound units to aid in sexing lake sturgeon to selectively implant transmitters in mature fish to track spawning movements. Similar efforts also occurred on the eastern end of Lake Erie and the Niagara River, where lake sturgeon movements were tracked with a large array of receivers. In the lower Niagara River 85 lake sturgeon have been tagged and a new array design was deployed to improve the ability to estimate fish position in the river as well as outside the river mouth. The Service continues to work with partners to expand arrays in Lake Ontario to answer broader scale movement questions. Telemetry results along with genetic analysis will give insights into lake sturgeon life history and population structure in eastern Lake Erie.

The Ashland FWCO maintained and expanded an acoustic telemetry network along the Lake Superior south shore in 2018. Seventeen receivers deployed in nearshore waters of Wisconsin and Michigan and ten receivers deployed in rivers were recovered, downloaded, and re-deployed. The Service's acoustic array now covers a shoreline distance of over 304 miles (490 kin). A total of 198 acoustic transmitters have been implanted into lake sturgeon captured in the spawning runs in the Bad River, WI, Sturgeon River, Ml, Ontonagon River, Ml, and while at-large in Lake Superior in Chequamegon Bay, WI and off the mouth of the Ontonagon River. Objectives are to examine movement, spawning tributary fidelity and spawning periodicity for adults, and to examine movement and spawning tributary selection of juveniles being stocked as part of rehabilitation efforts.

In the eastern portion of Lake Erie, the Service continued to track lake sturgeon by acoustic telemetry in the Buffalo Harbor and upper Niagara River areas. A total of 68 receivers were deployed to collect data on a total of 63 adult

lake sturgeon that have been tagged by the Northeast Fishery Center since 2014. These receivers have collected information on other species that have been acoustically tagged by other researchers in the area. Data are used to evaluate lake sturgeon movement, habitat use, and identify potential spawning sites. As a result of movement evaluation, egg mats were deployed in 2017 at multiple sites which resulted in the first confirmation of lake sturgeon spawning in the headwaters of the Niagara River.

In the lower Niagara River and Lake Ontario the Lower Great Lakes FWCO continued tagging adult lake sturgeon and expanding their acoustic array. To date, 85 adult lake sturgeon have been tagged and their movements tracked in the eastern basin of Lake Ontario. Some sturgeon have even been detected on receivers on the far end of the lake. These data are used to answer questions about habitat use, spawning timing, and residency within the river.

Habitat Restoration

The Service and partners have constructed eight spawning reefs in the St. Clair-Detroit River System since 2004 adding 20.64 acres of hard substrate to the system to remove the loss of fish and wildlife habitat and degradation of fish and wildlife populations beneficial use impairments in these rivers. In the spring of 2018 another 4 acre reef, the Fort Wayne reef, was constructed in the Detroit River. The reefs consist of loose rock strategically placed on the river bottom and replace natural spawning areas that were present in the St. Clair and Detroit Rivers before construction of commercial shipping channels removed much of the rocky habitat. The rock provides a safe place for eggs to incubate until the fish larvae hatch out and drffl down the river. Assessments are conducted to monitor the biological and physical response to each reef and results are used in an adaptive management process to guide future reef restoration projects. For more information on these projects please visit http://scdrs.org/.

In an effort to assess tributaries for lake sturgeon restoration in lakes Huron and Erie, the Service has been working with the University of Toledo and Lake Superior State University in order to develop habitat suitability models (HSI). Using side scan sonar technology the amount and type of substrate is determined in each tributary. This information along with water depth, water velocity, and other water chemistry variables are used to create a spatially explicit Hsl model for multiple life stages of lake sturgeon. The HSI models along with other information are being used to develop restoration plans for tributaries in lakes Huron and Erie.

Side scan sonar imagery collected in the Ausable River, MI, a tributary to Lake Huron.

Brook Trout

Broodstock Management

To provide a Lake Superior strain of brook trout for stocking in Lake Superior waters, the Service maintains the Tobin Harbor (Isle Royale) brood stock at Iron River NFH. Wild brook trout eggs/fish collected from Tobin Harbor by Iron River and Genoa NFH's and the Ashland FWCO are currently in isolation at Genoa NFH prior to planned transfer to Iron River NFH for infusion of new genetics into the brood line.

Production and Stocking

ln 2018, the Service's Iron River and Genoa NFH's cultured and stocked 15,000 Tobin Harbor strain yearling brook trout in Lake Superior waters in partnership with Grand Portage Band of Lake Superior Chippewa, Keweenaw Bay Indian Community, and Michigan DNR. All brook trout yearlings were adipose fin clipped and coded-wire tagged prior to stocking. Brook trout eyed-eggs were provided to Red cliff Band of Lake Superior Chippewa for rearing and stocking.

Status, Distribution, and Habitat

ln support of goals and objectives outlined in the Lake Superior Brook Trout Rehabilitation Plan, the Ashland FWCO implemented the Lake Superior Technical Committee standardized shoreline electrofishing index survey protocol at Tobin and Washington harbors, Isle Royale and Big Bay and Marquette, Ml, and Chequamegon Bay, WI. The standardized effort among fishery agencies examines coaster abundance and distribution, stocking success, and presence of non-native salmonines in key areas of Lake Superior shoreline Waters. The standardized approach allows a level of comparison among and within locations and may help agencies detect establishment of new populations in Lake Superior. In 2018, coaster CPUE (#/shoreline kin) in Tobin Harbor was 5.8, similar to 6.5 in 2017, while Washington Harbor CPUE was 2.0. In Big Bay CPUE was 0.6, while in Chequamegon Bay CPUE was 0.0.

In addition to monitoring population status and biological characteristics, the Ashland FWCO monitored presence of the copepod parasite, Scr/mi.nco/a edwcrrs/./., in coaster

brook trout at Isle Royale over the past 18 years. Annual Salmincola prevalence on coasters ranged from 65% to 100% and averaged 87% during a twelve year time-period from 2005-2017. This work was published in 2018, in the journal, *Hydrobiologia*.

The Ashland FWC0 continued to monitor brook trout movement between lake and stream environments at Isle Royale, Ml, and Chequamegon Bay, Wl using stationary PIT tag detection systems. Brook trout tagged in Washington Harbor have moved into Washington Creek during the spawning season, and returned to the harbor post spawning. Adults stocked in Whittlesey Creek moved downstream and out of Whittlesey Creek much quicker and at a higher percentage than stocked yearlings.

The Ashland FWCO and partner State, Tribal, and Federal fishery agencies, university researchers and NGOs Brook trout captured during status survey. continued to utilize brook trout population status and distribution data in the Lake Superior basin of Wisconsin and Michigan to prioritize fish passage and culvert removal projects and to identify priority watersheds for riparian and instream habitat restoration.

The Lower Great Lakes FWCO in partnership with NYDESC and other local groups, has been assessing road crossings for fish passage annually since 2010. Road crossings have been assessed using the North Atlantic Aquatic Connectivity Collaborative stream crossing assessment protocol. In 2018, approximately 180 road crossing assessments in high priority Great Lakes watersheds were completed. The information from these assessments will be used to prioritize funding for fish passage restoration projects.

Cisco

Production and Stocking

Lake Huron

ln 2018, the Service's Genoa and Jordan River NFH's cultured and released 1,146,515 fall fingerling cisco (Coregonus arted) into the Saginaw Bay region of Lake Huron in support of Lake Committee directives for the reestablishment of this important prey species. Stocked fish were released in a combination of offshore plants using the M. V. Spencer F. Bat.rd, and night shore releases. During these stocking events, an evaluation of both stocking techniques was conducted to assess handling stress. A small proportion of cisco were held in net pens overnight to evaluate post-stocking mortality. Cisco were held in net pens for 12-14 hours and morbid fish were enumerated. Less than 1% of the fish that were held in the net pens perished. In 2019, 1 million cisco are scheduled to be stocked in Saginaw Bay. All released fish were oxytetracycline marked for future assessment.

Lake Ontario

ln November 2018 the Service's Northeast Fishery Center stocked 279,000 fingerling cisco in Sodus Bay, New York, to meet a New York State Department of Environmental Conservation (NYSDEC) restoration request. All fish were marked with calcein for future evaluation purposes.

Bloater

Production and Stocking

Lake Ontario

ln 2018 the Service stocked 7,500 fall fingerling bloater offshore of Oswego NY. These fish were produced in cooperation with USGS, NYSDEC, and the Ontario Ministry of Natural Resources. All fish were marked with calcein for future assessment purposes.

Cisco, Bloater, and other Forage Fish

Assessments, Research, and Restoration

The Lake Superior Technical Committee has highlighted the need for a comprehensive cisco stock assessment that is capable of handling both fishery dependent and fishery independent information. Both Ashland FWCO and USGS biologists have collaborated with the Quantitative Fisheries Center (QFC) at Michigan State University to develop an age-based stock assessment model for the Thunder Bay cisco population. Results of this effort were shared with management agency personnel during a 2-day workshop held at the USFWS Regional Office in Bloomington, MN. During the meeting, staff from the QFC described the mechanics of the model and also charted a path for how similar models could potentially be built for other jurisdictions.

The statistical catch-at-age assessment model developed for Lake Superior cisco has highlighted the need for accurate hydroacoustic estimates. Members of the Lake Superior Technical Committee recognize that ship-based, down-looking acoustics could be a potential source of bias due to the limited sampling volume near the surface of the lake. Staff from the Ashland FWCO, USGS, Red Cliff Band of Lake Superior Chippewa, and the University of Minnesota-Duluth have initiated a study to better appreciate the vertical distribution of spawning cisco. A recently acquired acoustic sled will allow scientists to deploy transducers at greater depths so they can aim sound waves upwards and increase the volume of water sampled near the surface. This equipment will be used again in subsequent years and help to refine the methods by which Lake Superior cisco populations are assessed.

Lake Ontario's reintroduction program for bloater, a native species of deepwater cisco, was initially supported through fertilized eggs collected from Lake Michigan's bloater populations between 2012 and 2017. Extensive efforts were put forth to annually collect up to one million eggs that were

sent directly to Lake Ontario where, most importantly, Service and USGS facilities continue to improve methods to successfully rear the eggs to juvenile life-stages. To date these efforts have resulted in the total stocking of nearly 600,000 juvenile bloaters in Lake Ontario. This year January and February wild gamete collections were cancelled due to the Federal Government shutdown.

Cisco collected from Lake Huron.

In Lake Huron, management agencies approved a restorative stocking study for Cisco in Saginaw Bayunder the guidance of the Lake Huron Technical Committee. The Alpena FWC0 is leading efforts toobtain necessary fertilized gametes to support the Study's annual production target of 1 million fingerling Cisco. Following up on pilot work conducted in 2015 -2016 at the Les Cheneaux Islands and Drummond Island, this year's objective was to collect sufficient spawning to pairs to develop a third brood cohort, while concurrently providing eggs to meet production targets for stocking in 2019. Alpena FWC0 staff teamed with staff from the Jordan River, Iron River, Pendills Creek and Genoa NFH's to collect gametes from 140 spawning Cisco pairs during the fall of 2018. Field work for the project occurred over a period of two weeks, though the bulk of spawning pairs were collected during November 8-13. Fertilized gametes spawned for the third brood cohort were shipped to an isolation facility at the Genoa NFH for initial rearing, while the rest of the eggs intended for production were transported to the Jordan River NFH. Cisco collected from Lake Huron.

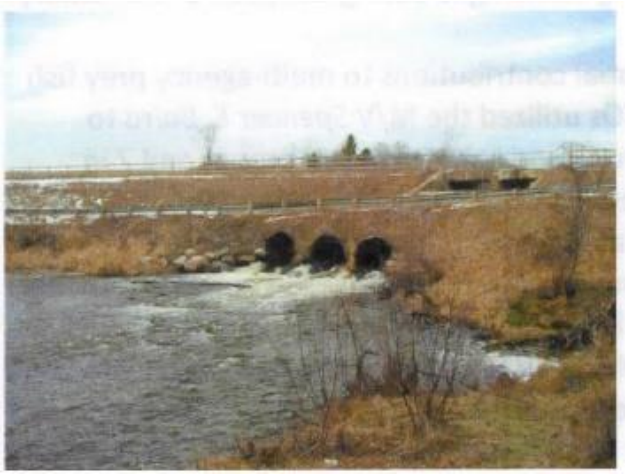
In addition to obtaining standard biological information, each spawning animal was assessed for fish health and morphometry (e.g., characteristics of its body proportions). Tissue samples were collected from all spawning animals for future genetic analyses. Furthermore, the field team provided gamete samples to the USGS Great Lake Science Center for development of genetic linkage map for Cisco as well as further genetics work. A field team also provided live adult Cisco to researchers at the Hammond Bay Biological Station for acoustic telemetry tag insertion on Cisco to assess habitat utilization and seasonal movement. Additionally the Alpena FWCO staff have been conducting early life history work for recruitment and distribution of Coregonids in Saginaw and Thunder Bays during the presumed peak emergence in the spring. Sampling has been done to determine if larval density differences can be detected, as well as an indicator of presence/ absence of Cisco in Saginaw Bay.

In Lake Ontario, Cisco populations have been greatly reduced with small remnant populations existing in Chaumont Bay and the Bay of Quinte. The Chaumont Bay population was identified as a possible source for restoration stocking. In partnership with NYSDEC and USGS, the Lower Great Lakes FWCO has initiated surveys to better understand the abundance and population characteristics of this spawning group. Additionally, 90 cisco have now been tagged with acoustic telemetry tags to assess habitat selection and characteristics for spawning. Movement data will be combined with side-scan sonar maps to help understand spawning site characteristics and selection.

The Alpena and Green Bay FWCOs continue to make substantial contributions to multi-agency prey fish assessments in Lakes Huron and Michigan. In 2018, the FWCOs utilized the M/V 5pencer F. Baird to perform a total of 18 hydroacoustic transects (6 on Lake Huron, 5 on Lake Michigan proper and 7 in Green Bay waters of Lake Michigan) to estimate fish densities. FWC0s conducted midwater trawls (15 on Lake Huron and 19 on Lake Michigan proper and Green Bay) to determine species and size compositions to pair with the acoustic data. Overall these surveys show total prey fish biomass remains at low levels. The Lake Huron prey community is dominated by a native deepwater cisco (Bloater) while the exotic alewife are still the primary prey species in Lake Michigan. This marks the eighth consecutive year of the Service's involvement in these surveys that provide critical information to the management and research communities regarding the status of important Great Lake's prey fish stocks.

Aquatic Habitat Restoration

ln support of fisheries and wildlife conservation across the Great Lakes basin, the Service provides funding and technical support through its Fish Passage Program, the Great Lakes Fish and Wildlife Restoration Act and the Great Lakes Basin Fish Habitat Partnership for terrestrial habitat restoration and enhancement projects that are part of larger, watershed-scale restoration efforts. These Service programs leverage the available resources of the many partners and stakeholders to implement the numerous on-the-ground projects in support of shared resource management priorities and species population goals. In 2018, GLRI habitat funds allocated to the Lower Great Lakes FWCO funded four projects: one dam removal, two stream restoration, and one combined aquatic, riparian and upland restoration on a small lake.



Before-Woodland Road, 3 undersized perched culverts; After: Timber Bridge at Woodland Road

In the upper Great Lakes, the Service continued to strategically apply the GLRl to restore river and stream habitat to conserve high priority trust resources. In 2018, we allocated our GLRl funds to projects that will improve habitat connectivity and bolster resiliency for priority five brook trout populations in Wisconsin and Michigan. In 2018, a GLRl funded project under the Great Lakes Fish and Wildlife Restoration Act with Ducks Unlimited titled `Restoring Fish Passage and Coastal Wetlands on Lakes St. Clair and Erie -Phase 1" completed the restoration of 13 acres of wetlands on three separate properties and 87 acres of grasslands on two separate properties in the Western Lake Erie Basin.

The Service marked a big year of accomplishments in 2018 on the Maple River near Pellston, Michigan, thanks to the completion of three GLRl-funded projects on the River. The removal of Lake Kathleen dam, and replacement of undersized and perched culverts at Woodland Road and Brutus road completed a long term effort to free span the entire Maple River reconnecting over 55 miles of high quality Brook Trout habitat.

The projects were also a great example of collaboration between U.S. Fish and Wildlife Service programs and the many partners involved by successfully working through complicated issues such as sea lamprey distribution, endangered Hungerford's crawling water beetle and Michigan Monkeyflower, and land/dam ownership changes.

Before: Lake Kathleen Dam Spillway; After: Lake Kathleen Dam Location after removal

Lake Superior Partnership Aquatic Community Committee

The Service, via the Ashland FWCO, serves as the U.S. Co-chair of the Lake Superior Partnership Aquatic Community Committee (ACC). In 2018, the Service contributed to the State of Lake Superior Conference held on the Michigan Technological University campus, by leading several sessions. The Service continued tracking progress on 5-year ACC work plans, annual reporting of LAMP project accomplishments, and Cooperative Science and Monitoring Initiative projects in support of GLWQA Annex 10 -Science. In support of Annex 2 -Lakewide Management Plan, the Service contributed to development of aquatic sections of the

Lake Superior LAMP 2015-2019, the first LAMP to be completed under the 2012 GLWQA.

Aquatic Invasive Species

Eurasian ruffe

ln addition to Aquatic Invasive Species (AIS) efforts targeting new non-native species, the Alpena and Lower Great Lakes FWCOs conducted targeted efforts to detect new populations of ruffe in Lakes Huron, Erie, and Ontario. Alpena FWC0 has been conducting annual ruffe surveillance since 1996. In 2018, efforts were conducted to detect ruffe in and around locations where they have been captured in the past and also to survey other Lake Huron ports in an effort to detect new populations. The Lower Great Lakes FWC0 has surveyed select port locations in both Lake Erie and Lake Ontario since 1994. In 2018, surveys were completed at all planned locations. In addition, biologists evaluated survey protocols to ensure effectiveness and consistency.

Asian Carp

The Service, in cooperation with its partners, currently implements two different strategies to address the threat of Asian carps to the Great Lakes: the Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States (Plan), which is national in scope, and the Asian Carp Regional Coordinating Committee's (ACRCC) Asian Carp Control Strategy Framework (Framework), which focuses on the Great Lakes region.

In 2018, the Service continued to lead implementation of actions identified in the National Plan; worked with partners to implement monitoring, control, rapid assessment, and electric barrier defense/clearing actions in the Chicago Area Waterway System (CAWS) as needed; assisted with updating and implementing a Monitoring and Response Plan for Asian Carp in the Upper Illinois River and CAWS under the Framework; served on and continued co-chairmanship of the ACRCC; served as webmaster of Asiancarp.us; performed risk analyses and species risk assessments for Asian carps and other AIS species; administered ANS grant programs to States and Tribes; with our partners, coordinated and implemented a Great Lakes basin-wide eDNA surveillance program for Asian carps; collected and examined thousands of water samples from all five Great Lakes, the Ohio River, Upper Mississippi River, and CAWS for the presence Asian carp DNA at the Whitney Genetics Laboratory; continued to implement the Regional triploid grass carp inspection program; and implemented a comprehensive, Great Lakes basin-wide aquatic nuisance species monitoring program with our partners. For more information on Asian carp eDNA sampling efforts: http://www.fws.gov/midwest/fisheries/eDNA.html.

DNA Sequencer at the USFWS: Whitney Genetics Lab

ln 2018, the Service worked with U.S. and Canadian resource management agency partners to develop strategies and recommendations to address invasive species issues of binational concern (e.g., grass carp reproduction in Lake Erie) under the Great Lakes Water Quality Agreement. The Service and DFO Canada serve as co-chairs of the Annex 6 Invasive Species Committee.

In 2018, the Alpena FWCO worked with federal, state, and university partners to implement/evaluate monitoring, control, and rapid response actions to assess/suppress grass carp populations in the Detroit River and tributaries to Western Lake Erie; and assisted with developing/implementing a Monitoring and Response Plan for Grass Carp in Lake Erie under the Framework. Surveys targeted adult grass carp, with limited larval. age-0. and juvenile sampling. These coordinated activities will continue into the field season of season of 2019 via a dedicated grass carp task force including the Alpena FWCO, Ohio DNR, Michigan DNR Michigan State University, the University of Toledo, and USGS.

The Water Resources Reform and Development Act of 2014 (WRRDA) was signed into law on June 10, 2014. As directed, the Service assumed a lead role in coordinating federal interagency efforts to address the threat of Asian carps in the Ohio River and Upper Mississippi River basins and their tributaries, including the CAWS. Per WRRDA, the Service led development of the second annual Report to Congress summarizing state and federal expenditures to manage the threat of Asian carps in these areas.

Great Lakes Early Detection Monitoring

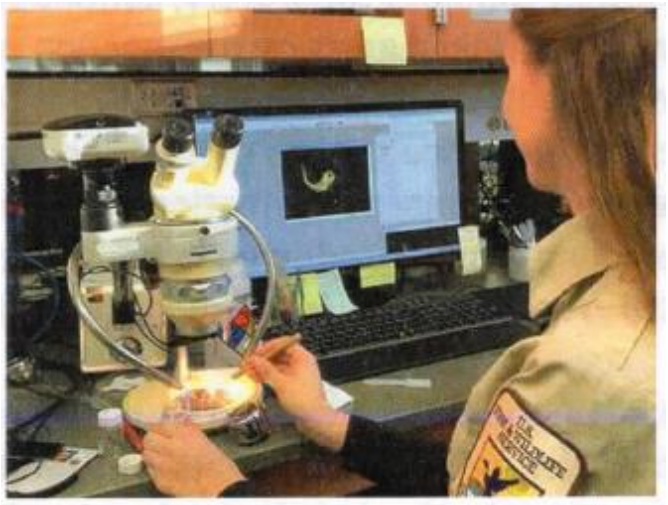
ln 2018, the Service continued ongoing sample collection for a monitoring program aimed at early detection of non-native fishes, amphipods, gastropods, and bivalves in the Great Lakes. This program is carried out across the Great Lakes by the Ashland FWCO, the Green Bay FWCO, the Alpena FWCO, and the Lower Great Lakes FWCO in conjunction with input from our partners. Early detection is critical for management of non-native species, particularly when trying to keep them from becoming invasive. Service biologists target high-risk sites around the Great Lakes where species are likely to be first introduced to the system.

Bongo nets are used to sample the icthyoplankton community as part of the Early Detection Program.

Detection techniques target all life stages for fishes, and focus mainly on adult bivalves, gastropods, and amphipods. Since 2013, thousands of samples were collected at high risk sites in the Great Lakes to search for a range of species that could be introduced to the Great Lakes from anywhere in the world. Genetic techniques are used in conjunction with standard identification methods to maximize species detection capabilities. The U.S. Environmental Protection Agency, USGS, and Ontario Ministry of Natural Resources and Forestry partner with the Service on sample collection and processing. Funding continues to be provided by the Great Lakes Restoration Initiative.

In 2018, the Green Bay FWCO conducted gear comparison studies that identified biases between varying crayfish trap designs used for Early Detection and Monitoring of crayfish. Peer reviewed findings of the study are being published this summer. In addition to the gear comparison study, the Green Bay FWCO conducted species targeted sampling for red swamp crayfish distribution in the Greater Chicago area with a university partner (Loyola U.) and discovered a new population of the crayfish in the Jackson Park Lagoons.

Collection efforts in Lake Superior in 2017 resulted in the February 2018 identification of a single bloody red shrimp in the lower St. Louis River bay near Duluth. Bloody red shrimp were discovered in Lakes Ontario and Michigan in 2006. They are now documented in all the Great Lakes. Bloody red shrimp also appear to be expanding within Lake Michigan, as the species was found in locations where it had not been previously detected.



A Service employee works to identify a larval fish captured as part of the Early Detection and Monitoring Program

Most of the remaining established AIS were consistently detected. Gears and methods for sampling fish were improved during 2018, allowing for geographic expansion of effort with similar, or better, efficiency compared to previous years. Benthic macroinvertebrate sampling took place where introduction and establishment would be most likely; including boat ramps, river mouths, and ship docking areas. ✧

Great Lakes Mass Marking Program 2019 (FWS)

The Great Lakes Mass Marking Program is collaboration between federal, state and tribal fisheries agencies, coordinated by the U.S. Fish and Wildlife Service, to answer questions critical for Great Lakes fisheries management. It is fully funded by the U.S. EPA's Great Lakes Restoration Initiative.

2018 Tagging and marking activities

- 3.7 million Lake trout, 2.9 million steelhead, & 2.4 million Chinook salmon were fin clipped in 2018; most of the lake trout and steelhead, and 1.0 million of the Chinook salmon, were also coded-wire tagged.
- 0.6 million each of Atlantic salmon, brown trout, brook trout, and splake were also marked in 2018
- 98.5% of Chinook salmon, lake trout, and steelhead were successfully clipped or tagged in the hatcheries
- Throughputs averaged 8,764, 7,564, and 7,424 fish/hr for Chinook salmon, lake trout and steelhead respectively.

2018 Data and tag recovery activities

- Fish and Wildlife Service bio-technicians stationed on Lakes Michigan and Huron, working with the states,

sampled 44 ports and examined 13,422 salmonines, including 4,577 Chinook salmon and 4,501 lake trout.

- About 101,000 coded-wire tags have been recovered since the inception of the project.

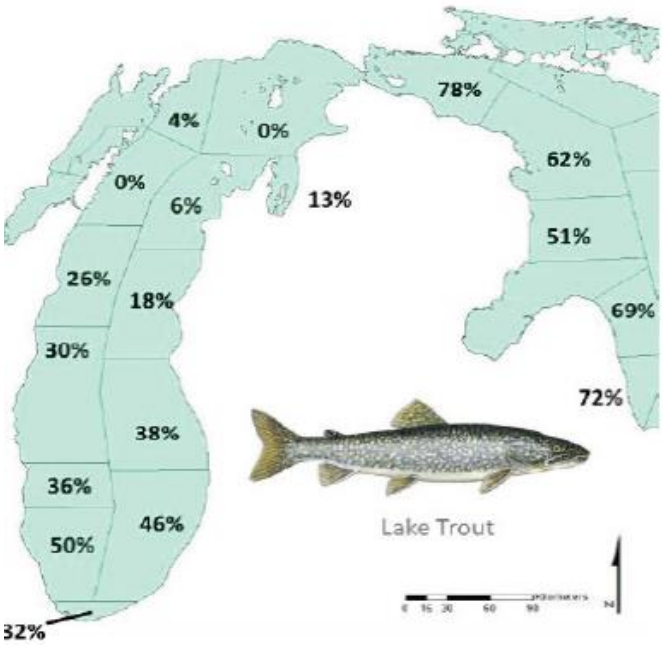


Fig. 1: Percent of lake trout recovered without a fin clip and presumed wild in each statistical district in 2018.

2018 Estimated contributions of wild lake trout to fisheries in Lakes Michigan and Huron

- 65% of lake trout recovered in Lake Huron had no fin clip and were presumed wild **(Fig. 1).**
- 30% of lake trout recovered in Lake Michigan had no fin clip and were presumed wild, and comprised a greater percentage of the catch in southern and central areas (Fig. 1).
- Catch per unit effort of wild lake trout increased over time in Lake Huron and southern Lake Michigan (**Fig. 2)**

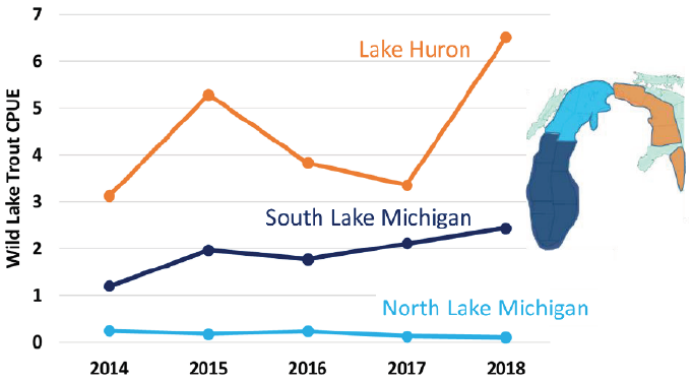


Fig. 2: Catch per unit effort (fish per sampling day) of wild lake trout collected by FWS biotechs in Lake Huron (orange), southern Lake Michigan (dark blue) and northern Lake Michigan (light blue).

2018 Estimated contributions of wild Chinook salmon to fisheries in Lakes Michigan and Huron

68% of Chinook salmon (all ages) recovered in Lake Michigan and 68% recovered in Lake Huron were without a fin clip and presumed to be wild **(Fig. 3**), consistent with values from the past several years. Estimated production of wild Chinook salmon from the 2017 year class was greater than the weak 2013 and 2015 year classes and was just below the level observed from most year classes from the mid- to late- 2000s **(Fig. 4**; blue bars are wild fish).

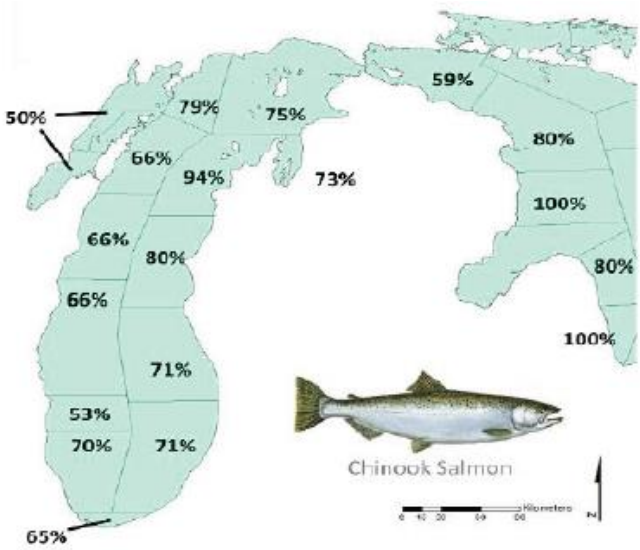


Fig. 3: Percent of Chinook salmon recovered without a fin clip and presumed wild in lakes Michigan and Huron.

Estimated contribution of stocked Chinook salmon to the fishery by stocking district

▪ Chinook salmon stocked on the western shore of Lake Michigan have greater survival after stocking than those stocked on the eastern shore and in Green Bay **(Fig. 5).** Even at eastern ports, fish stocked on the west shore tended to be caught the most (e.g., Frankfort, MI in **Fig. 8).**

Contributions of Chinook Salmon to the Open-Water Fishery

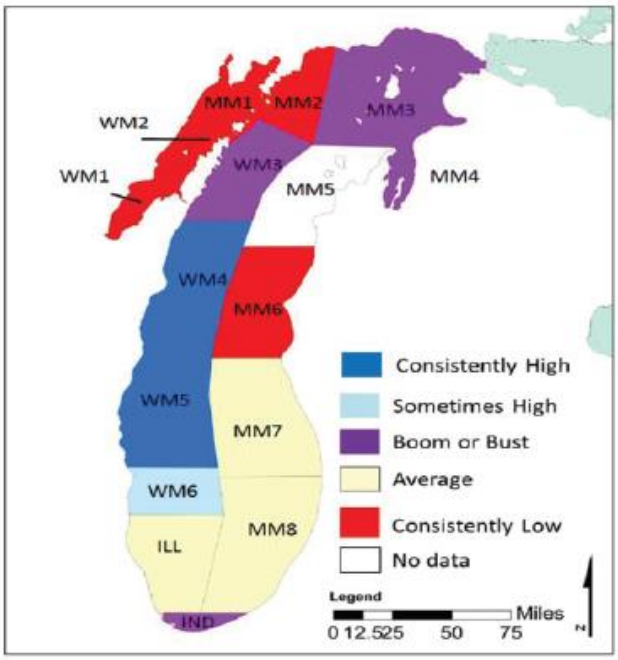


Fig. 5*: Districts where year classes (2011 – 2016) consistently had high survival (dark blue); sometimes had high survival (light blue); consistently average survival (yellow); highly variable survival depending on year class (purple); and consistently low survival (red).*

▪ Underlying mechanisms are unknown, but could include differences in habitat (e.g., water temperature, food availability) that make western shore locations favorable for young salmon; differences in rearing or release practices; greater competition with wild Chinook salmon on the eastern shore; or greater predation in Green Bay.

Chinook salmon growth patterns

▪ Chinook salmon stocked on the western shore grew slightly faster than those stocked elsewhere, mirroring survival patterns, but overall growth differences were minor, consistent with mixing due to lake wide salmon movement after stocking. Annual variability in Chinook salmon growth mirrored year-and older alewife density **(Fig. 6),** indicative of a limited food supply.

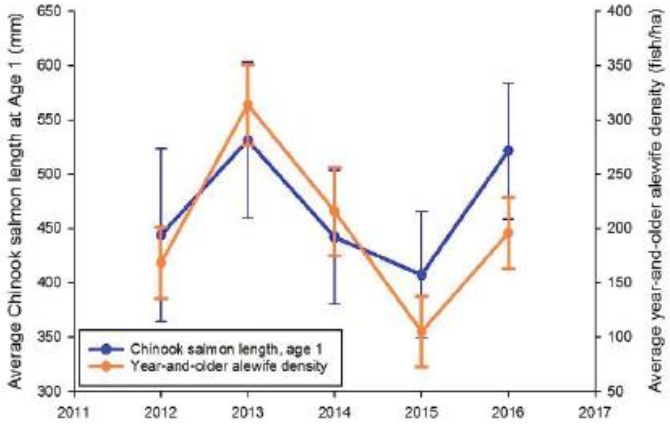


Fig. 6: Chinook salmon length at age 1 (blue line, left axis) tracks year-and-older alewife density (orange line, right axis)

Chinook salmon movements between lakes Huron and Michigan

▪ During April – August 2018, 88% of the recovered Chinook salmon that were stocked in Lake Huron were captured in Lake Michigan at age 1, consistent with values from prior years. However, fewer Lake Huron fish were captured in Lake Michigan at Age 2 (68%) and Age 3 (23%) than in prior years. Most mature Huron-stocked fish returned to Lake Huron in autumn to spawn.

▪ Chinook salmon move from Huron to Michigan with little reciprocal movement. Thus, a portion of Chinook salmon stocked in Lake Huron are considered as part of the Lake Michigan population for the purposes of the predator-prey ratio model, which is used to help maintain balance between predator and prey biomass in Lake Michigan.

Chinook salmon movement within Lake Michigan

▪ In the open-water fishery, over 90% of Chinook salmon were harvested in a different statistical district then where they were stocked during April – July. During Sept.-Oct.,

most (50-95% depending on age) were harvested in their stocking district. **(Fig. 7).** August was a transitional month.

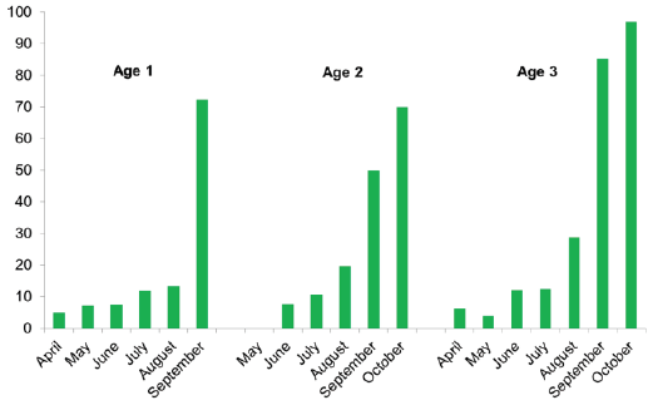


Fig. 7: Percent of Chinook from the 2011 year class recovered in the statistical district where they were stocked, by age and by recovery month. Patterns for later year classes were similar.

- Mean distance between the centers of stocking and recovery districts during the open-water fishery was 73 - 94 miles depending on age, with recoveries up to 323 miles away from stocking location

- Fishing quality in spring and summer is not dependent on local stocking numbers, but may be affected in the fall.

- Maps showing the stocking locations of coded-wire tagged Chinook landed at specific ports (31 in Lake Michigan, 11 in Huron, e.g., **Fig. 8**) are available upon request (matthew_kornis@fws.gov).

Post-release survival of lake trout stocked at historical spawning reefs

- Analysis of coded-wire tagged lake trout recovered by spring gill net assessment surveys showed that lake trout catch rates (CPUE, corrected for number of fish stocked and a proxy for survival) was primarily affected by stocking location and genetic strain.

- Lake trout CPUE was lowest from fish stocked in the Northern Refuge, due in part to mortality from sea lamprey and commercial fishing, and highest from fish stocked at Julian's Reef.

- In stocking locations with low lake trout mortality, Lake Michigan remnant genetic strains, Lewis Lake and Green Lake, had higher CPUE than Seneca Lake strain.

- High CPUE of lake trout stocked in southern Lake Michigan may have contributed to increased recoveries of wild lake trout recently reported from that area by building spawning stock biomass.

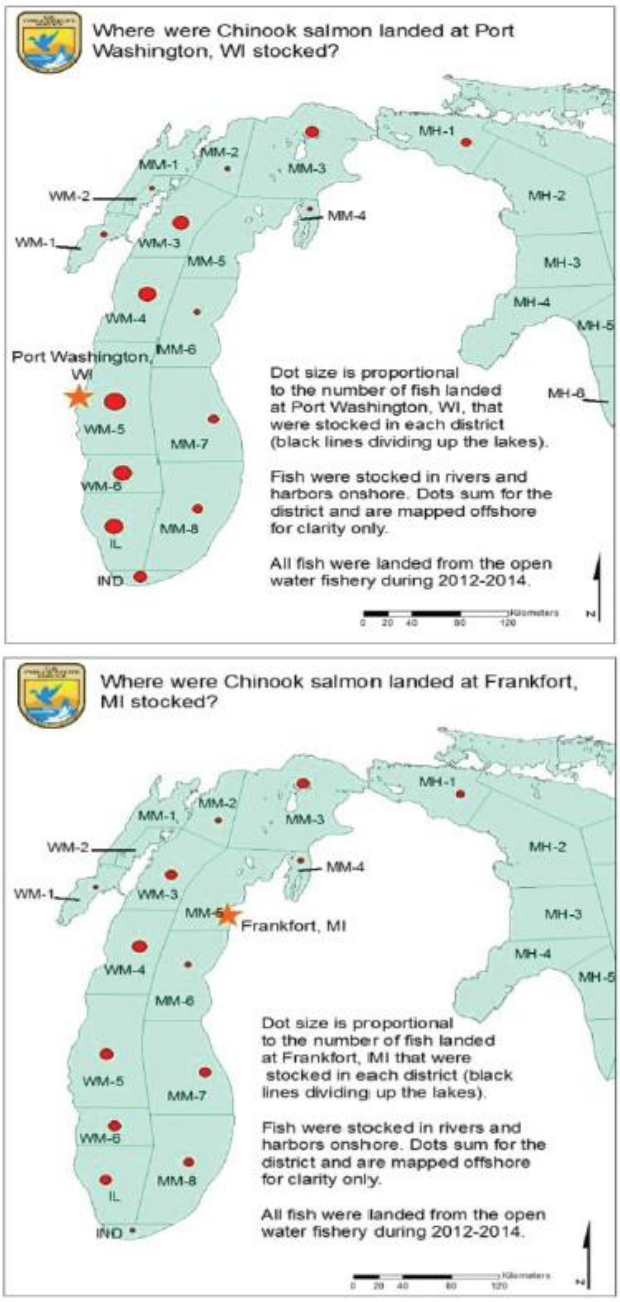


Fig. 8: Origin of stocked Chinook salmon captured at Port Washington, WI (left) and Frankfort, MI (right) from 2012 – 2014 during the open water fishery. The size of each red circle corresponds with the number of fish per 100,000 stocked recovered at the identified harvest location (gold star).

Post-release movement of lake trout stocked at offshore reefs

- Over 50% of lake trout stocked offshore in southern Lake Michigan were recovered in nearshore waters accessible to the recreational fishery **(Fig. 9).** Spread of lake trout from northern Lake Michigan was more limited.

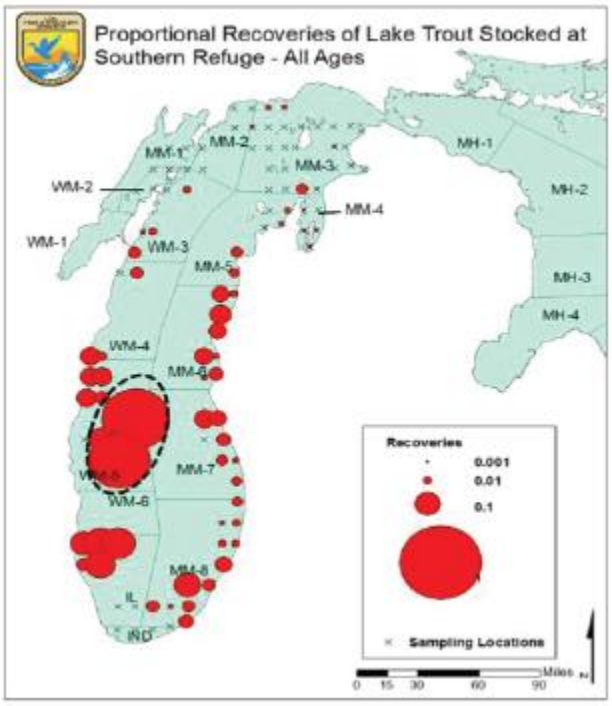
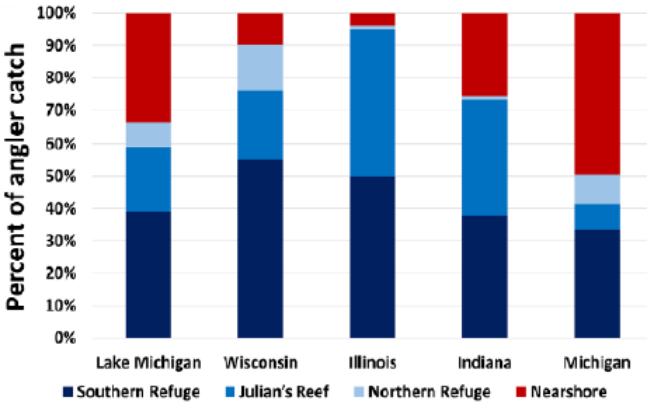


Fig. 9: Catch rate (CPUE) of lake trout stocked offshore at the Southern Refuge (dashed black oval). Dot size is proportional to CPUE. X's are sampling sites.

▪ Analysis of angler-caught lake trout from 2012-2018 suggested lake trout stocked offshore contributed more to angler catches **(Fig. 10, left**) and had greater returns per number stocked (**Fig. 10, right**) than those stocked nearshore.

▪This may be due to better survival of lake trout stocked at offshore locations, and contradicts the belief that lake trout must be stocked nearshore to benefit anglers.



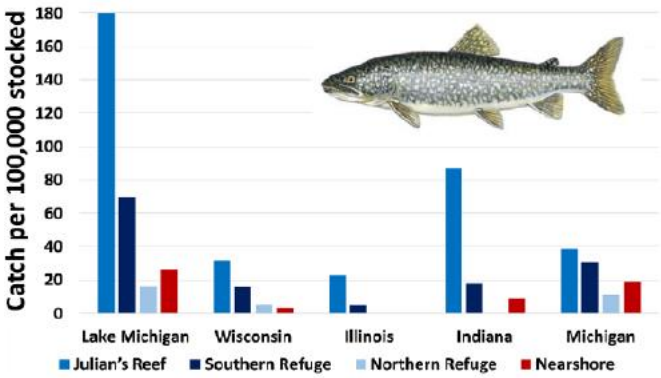


Fig. 10: Percent of angler catch (left) and return rates corrected for number of fish stocked (right) of lake trout from offshore (blue bars) and nearshore (red bars) stocking locations in Lake Michigan.

Diets of Lake Michigan salmon and trout

▪ Stable isotopes of carbon (δ13C, indicates offshore vs. nearshore foraging) and nitrogen (δ15N, indicates food web position) were analyzed to assess diet and potential for competition.

▪ Lake trout were unique, with <25% overlap with Chinook salmon, coho salmon and steelhead, and had a greater reliance on bottom-oriented and offshore prey (goby, bloater, sculpin; **Table 1).**

Predator	Alewife & Smelt	Bloater	Sculpin	Round Goby	Stickleback
Lake Trout	54	15	15	10	6
Chinook Salmon	85	1	0	6	8
Coho Salmon	80	1	1	12	6
Rainbow Trout	78	1	1	15	6
Brown Trout	72	2	2	13	10

Table 1: Percentage of fish prey in Lake Michigan salmon and trout diets as estimated by stable isotope mixing models. Values are lake-wide averages; diets vary among regions, seasons, and individual fish. Numbers may not add to 100% due to rounding.

▪ Pacific salmon species (Chinook salmon, coho salmon, and steelhead) were very similar isotopically, suggesting similar diet.

▪ Results suggest competition for declining alewives and rainbow smelt will be highest among Chinook salmon, Coho salmon, and steelhead. ✧

Great Lakes Fish Tag/Recovery Lab Tagging and Marking Activities, 2018 (FWS)

Introduction

Fisheries managers in the Great Lakes, along with the USFWS, annually stock over 20 million salmonines to diversify sport fisheries, restore native fish populations, and control invasive fishes. However, information is required to determine how well these fish survive and contribute to commercial and recreational fisheries and the levels of natural reproduction by native and non-native salmonines. To this end, the Council of Lake Committees (CLC), a basin-wide group of fishery managers that operates under the auspices of the Great Lakes Fishery Commission, agreed in 2005 to promote the development a basin-wide program to tag and/or mark (fin-clip) all stocked salmonines. This effort would provide greater insight into survival and movement of stocked salmonines, the contribution of stocking to the restoration of native lake trout, the ability to manage harvest away from wild fish, and the opportunity to evaluate and improve hatchery operations.

The CLC requested that the USFWS deliver a basin-wide mass marking program based on its successful delivery of the basin-wide sea lamprey control (U.S. agent) and lake trout restoration programs. To address this request, the Great Lakes Fish Tag and Recovery Laboratory was established at the Green Bay Fish and Wildlife Conservation Office in New Franken, WI. Pilot tagging and marking operations began in 2010 and recovery of tagged fish began in 2012.

In 2018, the Lab's tagging and marking staff consisted of three AutoFish trailer operators, one data analyst/statistician, and one supervisory biologist. The program's tagging trailer fleet consists of four automated tagging and marking trailers and one manual trailer. In 2018, the lab staff used these trailers to coded wire tag and/or adipose fin clip 9,850,763 trout and salmon at fifteen state and federal hatcheries. The Great Lakes Restoration Initiative, managed by the USEPA, provided annual operational funding of $ million through a request made by the USFWS, Region 3. Additional funding was provided by other GLRI funds for lake trout restoration.

Summary of Chinook Salmon Tagging and Marking Operations

For the years of 2011-2016, all Chinook salmon stocked into Lake Michigan and the U.S. waters of Lake Huron received a coded wire tag and an adipose fin clip (ADCWT). Starting in 2017, due to a shift in funding priorities, most of the hatchery reared Chinook salmon were only adipose fin clipped (AD only) with the balance being coded wire tagged and clipped to support ongoing state sponsored research projects. Using the automated trailers in 2018, the lab tagged and/or clipped a total of 2,385,654 Chinook salmon. These efforts required coordination and cooperation with six state-administered hatcheries in Michigan, Wisconsin, Indiana, and Illinois.

Table 1. Total numbers of Chinook salmon processed and project completion dates by hatchery in 2018

Hatchery	Agency	# tagged & clipped	# AD only clipped	Date complete
Jake Wolf	Ill DNR	0	174,629	3/10/18
Mixsawbah	Ind DNR	0	67,732	4/4/18
Wild Rose	Wis DNR	132,874	697,254	4/24/18
Wolf Lake	Mich DNR	151,002	249,963	3/28/18
Platte River	Mich DNR	370,570	152,117	5/2/18
Thompson	Mich DNR	317,236	72,277	5/7/18
Total Chinook		971,682	1,413,972	

Chinook salmon tagging/clipping performance comparison 2010 - 2018

This year had continued high performance in efficiency and throughput that is attributable to consistent operator experience, and to hardware and software improvements. The average throughput has remained consistent at more than 8,300 fish/hour for the past seven years. (Table 2). (During processing with the automated system, the coded wire tagging operation occurs simultaneously with the clipping operation, therefore, realized throughput is not significantly different for AD only and ADCWT groups.)

Table 2 Number of Chinook salmon processed and average throughput for 2010-2018 tagging projects for all hatcheries combined.

Year	# fish processed	# machine Run hours	Average Throuthput
2010	1,104,166	162.0	6,816
2011	4,689,947	667.4	7,027
2012	4,320,884	518.9	8,327
2013	2,856,038	319.0	8,953
2014	2,953,814	321.6	9,185
2015	2,968,797	323.2	9,186
2016	2,769,628	322.1	8,599
2017	2,130,882	235.6	9,044
2018	2,385,654	272.2	8,764

Summary of Lake Trout Tagging Operations

Since 2010, all lake trout have been coded wire tagged and adipose fin clipped at USFWS hatcheries in Region 3 (Lakes Michigan and Huron), and since 2012 all lake trout at USFWS hatcheries in Region 5 (Lakes Erie and Ontario) have been tagged and clipped. In 2018, 3,014,543 fish were tagged and clipped at three Region 3 hatcheries, and 563,874 fish at one Region 5 hatchery (Table 3).

Table 3. Total numbers of lake trout processed and project completion dates by hatchery in 2018

Hatchery	Agency	Number tagged	Date completed
Jordan River l Fish Hatchery	FWS Reg 3	492,801	9/18/2018
Pendill's Creek Fish Hatchery	FWS Reg 3	1,102,665	9/9/2018
Iron River Fish Hatchery	FWS Reg 3	1,419,077	10/2/2018
Allegheny Fish Hatchery	FWS Reg 5	563,874	9/11/2018

Lake trout tagging performance comparison 2010 - 2018

A continued high level of efficiency and throughput was maintained in 2018 that was attributable to consistent operator experience, and hardware and software improvements. Throughput across all hatcheries has averaged 7,751 fish/hour over the last six years, and has increased from under 5,500 fish/hour in 2010 (Table 4).

Table 4. Total numbers of lake trout processed and throughput for 2010 - 2018 tagging projects for all hatcheries combined.

Year	Number of fish processed	# machine Run hours	Average Throuthput
2010	4,584,509	837.5	5,474
2011	5,077,425	796.6	6,374
2012	6,094,302	856.7	7,114
2013	5,660,034	697.3	8,117
2014	6,412,006	791.1	8,105
2015	6,389,825	839.9	7,608
2016	4,916,035	691.3	7,111
2017	3,711,587	463.7	8,004

Summary of Steelhead Tagging and Marking Operations

For 2011-2016, all Chinook salmon stocked into Lake Michigan and the U.S. waters of Lake Huron received a coded wire tag and an adipose fin clip. Starting in 2017, coded wire tagging was shifted to hatchery reared steelhead that are stocked into lakes Michigan and Huron. As with the Chinook salmon, steelhead are reared and stocked by state agencies. Using the automated trailers, the lab coded wire tagged and adipose fin clipped 2,282,335 steelhead and marked 632,274 steelhead with only an adipose fin clip at eight state hatcheries. **(Table 5).**

The steelhead in Great Lakes hatcheries are comprised of six different strains, each with unique behavioral and biological characteristics. Some of these traits, such as the high size variability within cohorts and varying life cycles, complicate the logistics of automated marking and tagging of steelhead compared to lake trout or Chinook salmon. Differences in life cycles among strains result in a wide variety of times that the fish reach the optimum size for tagging, that range from March to November. Some hatcheries rear multiple strains that vary in size to the extent that multiple visits to a single hatchery are required to process all fish at that site. These multiple visits increase the complexity of the tagging schedule and costs related to trailer transportation and personnel travel.

There is also considerable size variation within rearing groups. This variability may be attributed to extended spawning seasons that requires multiple egg takes over many weeks or may simply represent differing feeding behaviors among individuals. The automated tagging system must be configured to process a given group of fish by using size-specific parts to optimize accuracy and efficiency; large size ranges within groups greatly complicates this optimization, and throughput and accuracy suffer. The average throughput for steelhead varied among projects and averaged 7,424 fish per hour – which is below rates achieved for most lake trout and Chinook salmon projects **(Table 5).**

Table 5. Total numbers of Steelhead processed and average throughput by strain and hatchery in 2018.

Hatchery	Agency	Dates	Strain	Number	Run hours	Fish/hour	Average total length (mm)
Jake Wolf	Illinois Department of Natural Resources	3/11 - 13	Arlee Rainbow trout	61,026	10.0	6,103	78
Jake Wolf	Illinois Department of Natural Resources	5/22 - 23	Skamania Steelhead	52,488	8.7	6,033	84
Mixsawbah	Indiana Department of Natural Resources	6/26 - 29	Skamania Steelhead	183,021	30.3	6,040	83
Mixsawbah	Indiana Department of Natural Resources	10/31 – 11/2	Lake Michigan Steelhead	124,260	18.5	6,717	84
Bodine	Indiana Department of Natural Resources	7/10-12	Skamania Steelhead	137,526	22.8	6,032	85
Bodine	Indiana Department of Natural Resources	11/5	Lake Michigan Steelhead	41,191	6.9	5,970	89
Harietta	Michigan Department of Natural Resources	9/22 - 24	Eagle Lake Rainbow trout	61,248	10.4	5,889	91
Wolf Lake (ADCWT)	Michigan Department of Natural Resources	9/26 – 10/23	Lake Michigan Steelhead	748,225	95.7	7,818	83
Wolf Lake (AD only)	Michigan Department of Natural Resources	9/29 – 10/24	Lake Michigan Steelhead	249,250	30.3	8,226	86
Kettle Moraine	Wisconsin Department of Natural Resources	10/11 - 12	Skamania Steelhead	72,837	8.9	8,184	101
Kettle Moraine	Wisconsin Department of Natural Resources	10/13 - 17	Chambers Creek Steelhead	124,514	15.2	8,192	89
Kettle Moraine	Wisconsin Department of Natural Resources	10/13 - 25	Ganaraska Steelhead	123,459	15.2	8,122	75
Lake Mills	Wisconsin Department of Natural Resources	6/5 - 8	Arlee Rainbow trout	105,225	16.4	6,416	90
Thompson (ADCWT)	Michigan Department of Natural Resources	10/17 – 11/6	Lake Michigan Steelhead	447,315	54.4	8,223	85
Thompson (AD only)	Michigan Department of Natural Resources	10/21 – 11/7	Lake Michigan Steelhead	383,024	48.9	7,833	85
Total Steelhead				2,914,609	392.6	7,424	

Summary of Tagging and Marking Operations for Other Species

When logistically feasible, the Lab has continued to support Great Lakes fisheries management by providing fish tagging and marking support on projects outside of the primary focus areas. In 2018, 874,567 fish from four additional species were tagged and/or marked using the automated system; the application of this technology is unique to the Great Lakes program these four species.

Table 6. Total numbers of fish of other species processed in 2017 (AD only = adipose fin clip only, ADCWT = adipose fin clip and coded wire tag).

Species	Hatchery	Agency	Operation	# fish	Date completed
Brown Trout	Les Voight	WI DNR	AD only	234,471	7/26/18
Brown Trout	Wild Rose	WI DNR	AD only	380,285	7/19/18
Atlantic Salmon	Platte River	MI DNR	ADCWT	111,674	7/29/18
Brook Trout	Iron River	FWS Reg 3	ADCWT	75,030	9/14/18
Splake	Les Voight	WI DNR	AD only	73,107	7/30/18

These projects represent the only applications of the automated tagging system for these species. This experience provides valuable insight on how differences in morphology and behavior among species affect the system performance and throughput compared to lake trout and Pacific salmon, and suggests that future tagging and marking projects for other salmon and trout species are possible.

Recoveries of fish from Lakes Michigan and Huron

During April 20 – September 30, 12 Service biological technicians worked with Wisconsin, Michigan, Illinois and Indiana DNRs to sample sport-caught salmon and trout on Lakes Michigan and Huron. Technicians engaged anglers at various ports and boat landings, with collection efforts concentrated at fish cleaning stations and fishing tournaments. Technicians collected biological data (**Table 7)** including length, weight, fin clip, sex, maturity stage, lamprey wounding and aging structures from 13,422 salmonines. Scales, otoliths, or maxillae were also collected from over 2,262 wild Chinook salmon and lake trout to estimate age and year class membership. Service technicians collected over 3,600 snouts from fish that had an adipose fin-clip only, producing 3,148 tag recoveries.

The Lab continued to collaborate on multiple cooperative studies in 2017. Stomachs and muscle tissue plugs were collected from 1,142 salmonines to analyze diets, via gut contents and stable isotope analyses, in the rapidly changing food webs of Lakes Michigan and Huron. Viscera, belly flaps, and dorsal muscle tissue were collected from 146 lake trout and 99 Chinook salmon to help understand the physiological response to sea lamprey attacks by analyzing total lipid and protein content. Otoliths from 570 steelhead and 678 Chinook salmon were collected for two separate otolith microchemistry studies that will determine the proportion of wild steelhead and Chinook salmon that originate from different natal streams in Lakes Michigan and Huron.

All hatchery reared lake trout, and all 2011 – 2018 year class hatchery-reared Chinook salmon, which seldom reach Age 4 or greater, have been fin clipped. Therefore, all lake trout and Chinook salmon recovered in 2018 that lack a fin clip are presumed to be naturally reproduced (wild). Pre-release QA/QC checks, and inspection of unclipped Chinook salmon for CWTs, show that fin clip error or regeneration is extremely low at about 0.5% total. Pre-release QA/WC checks indicate a similarly low fin clip error rate on lake trout. The percent of wild Chinook salmon and Lake Trout (without a fin clip) was determined for each jurisdiction **(Table 8).** A summary of all 2012-2018 sampling activities on Lakes Michigan and Huron is in Appendix VI.

Table 7. Number of fish by species examined by USFWS for CWTs from Lake Michigan and Lake Huron in 2018.

State of landing	Chinook salmon	Lake trout	Steelhead	Coho salmon	Brown trout	Atlantic salmon	Pink salmon	Total
Wisconsin	2882	1040	1149	1282	283	1	17	6654
Michigan – L. Huron	155	865	47	151	2	50	5	1275
Michigan – L. Mich.	1243	1565	207	247	16	2	0	3280
Illinois	93	240	65	159	5	0	2	564
Indiana	204	791	192	457	5	0	0	1649
Totals	4577	4501	1660	2296	311	53	24	13422
Number and % wild	3045 (66.5%)	1527 (33.9%)						

Table 8. Percent of examined Chinook salmon and lake trout in each sampling jurisdiction that did not have any fin clips and were presumed to be wild.

Sampling jurisdiction	Wild Chinook salmon	Wild lake trout
Wisconsin – Lake Michigan	65.0%	30.0%
Michigan – Lake Huron	68.1%	65.0%
Michigan – Lake Michigan	76.7%	23.1%
Illinois	70.1%	49.5%
Indiana	65.9%	31.6%

Tag Extraction Activities

Since the mid-1990s, the Great Lakes Fish Tagging and Recovery Lab has extracted coded wire tags for tagged fish collected by all agencies on Lake Michigan. In 2011, the lab expanded this service to all agencies throughout the Great Lakes. Sources were: salmon and trout caught by anglers at tournaments, fish cleaning stations or voluntary returns collected by USFWS and state agency technicians; charter boats; agency assessments; tribal commercial fishery assessments; and spawning returns to weirs and hatcheries. Prior to 2016, most snouts from tagged fish were sent to Green Bay for coded wire tag extraction, code wire tag reading, and data entry. Starting in 2016, most of the tag extractions were done by USFWS technicians at their partner agency field stations. In 2018, the Lab processed 16,948 samples from eight agencies and recovered 14,393 tags **(Table 9).**

Table 9. Number of coded wire tag samples processed by the USFWS in 2018.

Source or cooperating partner agency	Number of heads processed	Number of tags lost during processing	Percent lost tags	Number with no tag found	Percent with no tag found
Grand Traverse Band of Ottawa and Chippewa Indians	690	16	2.3	34	4.9
Illinois Department of Natural Resources/Fish and Wildlife Service	244	4	1.6	26	10.6
Indiana Department of Natural Resources/Fish and Wildlife Service	538	14	2.6	49	9.1
Little River Band of Ottawa Indians	475	14	2.9	30	6.3
Little Traverse Bay Band of Odawa Indians	692	11	1.5	34	4.9
Michigan Department of Natural Resources/Fish and Wildlife Service	8,297	134	1.6	1147	13.8
Sault Tribe Natural Resources Department	411	8	1.9	5	1.2
Wisconsin Department of Natural Resources/Fish and Wildlife Service	5,601	123	2.1	552	9.8
Totals	16,948	324	1.9	1877	11.0

Outreach and Data Analysis Activities

Lab scientists provided significant analytical support to Great Lakes fisheries managers in 2018. Examples of direct support include providing annual evaluations of Chinook salmon and lake trout survival, catch, and wild reproduction; assisting with developing subsampling strategies during weir collections; assisting with designing an experiment to test effects of a proposed change to commercial whitefish fishing regulations; evaluating effects of net pens on Chinook salmon return rates; and providing figures, reports, and PowerPoint slides as requested for state communications with their constituents. In addition, lab scientists authored or co-authored nine studies submitted to or published in scientific journals during 2018.

An assessment of Chinook salmon tag recoveries over several year classes was updated to include 2018 data and continued to show that Chinook salmon stocked on the western shore of Lake Michigan consistently survive better than those stocked on the eastern shore and in Green Bay. Origin of Chinook salmon harvested by anglers in each jurisdiction, and recovery locations of Chinook salmon stocked in each jurisdiction, were determined and shared with state partners. In-depth analysis of survival of Chinook salmon by tag lot from different stocking units (e.g., counties) were also provided as requested by state partners to assist with stocking management decisions. Finally, results suggested modest spatial variability in Chinook salmon growth rates as well as strong inter-annual variability tied to alewife abundance; this study was submitted to a peer-reviewed journal in 2018 and will be resubmitted in 2019.

Lab biologists also contributed to a study that found Chinook salmon stocked in Lake Huron began to move into Lake Michigan to feed after collapse of alewife in Lake Huron in the mid-2000's. This study was published in the *North American Journal of Fisheries Management* in 2018. Lab scientists continue to evaluate inter-lake movement of Chinook salmon on an annual basis and share those data with state and tribal partners. In 2018, a lower percentage of Huron-stocked Chinook salmon were recovered in Lake Michigan, particularly for older fish, a shift that may be related to recent increases in forage fish abundance in Lake Huron.

Recoveries of lake trout with legacy coded-wire tags (1985-2003) showed that post-release survival was lowest for fish stocked in northern Lake Michigan, corresponding with high levels of fishing and sea lamprey induced mortality in that area. At southern locations, post-release survival was higher from Lake Michigan remnant genetic strains and from fish with larger lengths at stocking. Strong survival and robust age classes of parental stock from southern locations corresponded with recent observations of increased wild recruitment. A manuscript containing these findings is currently *in review* with the *North American Journal of Fisheries Management*.

Lab scientists also published a paper in *North American Journal of Fisheries Management* that described the successful application of automated marking and tagging technology to brook trout as well as tag loss rates for that species.

Results indicated sustained natural reproduction and substantial movement of Chinook salmon and lake trout. For 2018, 68% of Chinook salmon recovered from Lake Michigan and 68% from Lake Huron were of wild origin, consistent with values from the past several years. There is also significant movement of stocked Chinook salmon among Lake Michigan jurisdictions, and from Lake Huron into Lake Michigan.

Wild lake trout recoveries from the 2018 Lake Michigan sport fishery were higher in southern and western Lake Michigan (26 – 50 %) than elsewhere (0 – 18%). Percent wild increased in 2018 relative to 2017 in most statistical districts, and lakewide percent wild increased from 16 – 17 % in 2014 – 2016 to 26% in 2017 and 30% in 2018, suggesting continued progress toward increased natural reproduction. In Lake Huron, 65 % of sport-caught lake trout were wild in 2018, continuing an increasing trend (50 – 57 % in 2014 – 2017). Early returns of 2010-2016 year classes of lake trout that were all tagged suggest offshore-stocked fish contribute more to recreational angler harvest than nearshore-stocked fish.

Appendix I

Details of Chinook salmon and lake trout tagging and marking projects in 2018

Hatchery	Agency	Species	Number tagged and clipped	Number clipped only	Number of tag codes	Start date	Complete date	Total machine run hours	Average fish/hour	Mean total length (mm)	Range of total length (mm)	Average coefficient of variation (CV)	Range of CV (mm)
Jake Wolf	Illinois Dept. of Natural Resources	Chinook salmon	0	174,629	0	3/8/18	3/10/18	22.0	7,938	92	92 - 92	6.6	6.6 – 6.6
Mixsawbah	Indiana Dept. of Natural Resources	Chinook salmon	0	67,732	0	4/2/18	4/4/18	10.5	6,451	87	87 - 87	9.2	9.2 – 9.2
Wild Rose	Wisconsin Dept. of Natural Resources	Chinook salmon	132,874	697254	4	4/10/18	4/24/18	81.1	10,000	81	78 - 85	6.2	5.7 – 6.5
Wolf Lake	Michigan Dept. of Natural Resources	Chinook salmon	151,002	249,963	2	3/21/18	3/28/18	56.6	7,296	84	79 - 87	8.8	8.0 – 10.3
Platte River	Michigan Dept. of Natural Resources	Chinook salmon	370,570	152,117	1	4/25/18	5/2/18	60.0	9,071	83	81 - 84	9.1	8.3 – 9.8
Thompson	Michigan Dept. of Natural Resources	Chinook salmon	317,236	72,277	1	5/2/18	5/7/18	42.0	9,416	81	80-82	9.3	8.5 – 10.1
	Chinook salmon totals and means:		**971,682**	**1,413,972**	**8**	**3/8/18**	**5/7/18**	**272.2**	**8,500**	**83**	**78 - 92**	**7.9**	**5.7 – 10.3**
Jordan River	U.S. Fish and Wildlife Service	lake trout	492,801	0	9	8/15/18	9/18/18	67.6	7,322	93	84 - 96	9.8	8.6 – 10.7
Pendills Creek	U.S. Fish and Wildlife Service	lake trout	1,102,665	0	15	8/7/18	9/9/18	145.7	7,659	96	92 - 100	8.0	7.2 – 8.8
Iron River	U.S. Fish and Wildlife Service	lake trout	1,419,077	0	18	9/14/18	10/2/18	182.4	7,731	91	87 - 99	8.5	7.2 – 10.3
Allegheny	U.S. Fish and Wildlife Service	lake trout	563,874	0	14	9/6/18	9/12/18	82.6	7,659	93	90 - 107	9.0	7.7 – 11.1

Appendix II

Details of Steelhead tagging and marking projects in 2018

Hatchery	Agency	Strain	Number tagged and clipped	Number clipped only	Number of tag codes	Start date	Complete date	Total machine run hours	Average fish/hour	Mean total length (mm)	Range of total length (mm)	Average coefficient of variation (CV)	Range of CV (mm)
Jake Wolf	Illinois Dept. of Natural Resources	Arlee Rainbow	61,026	0	1	3/11/18	3/13/18	10.0	6,103	78	78 - 78	10.3	10.3 – 10.3
Jake Wolf	Illinois Dept. of Natural Resources	Skamania	52,488	0	1	5/22/18	5/23/18	8.7	6,033	84	84 - 84	9.3	9.3 – 9.3
Mixsawbah	Indiana Dept. of Natural Resources	Skamania	183,021	0	3	6/26/18	6/29/18	30.3	6,053	83	82 - 84	12.0	10.5 – 13.9
Mixsawbah	Indiana Dept. of Natural Resources	Lake Michigan	124,260	0	1	10/31/18	11/2/18	18.5	6,720	84	81 - 90	15.8	14.4 – 18.0
Bodine	Indiana Dept. of Natural Resources	Skamania	137,526	0	3	7/10/18	7/12/18	22.8	6,115	85	82 - 87	14.0	13.4 – 14.5
Bodine	Indiana Dept. of Natural Resources	Lake Michigan	41,191	0	1	11/5/18	11/5/18	6.9	5,970	89	89 - 89	16.8	16.8 – 16.8
Wolf Lake	Michigan Dept. of Natural Resources	Lake Michigan	748,225	249,250	9	9/26/18	10/24/18	126.0	8,442	84	76 - 93	8.1	6.4 – 9.9
Thompson	Michigan Dept. of Natural Resources	Lake Michigan	447,315	383,024	5	10/17/18	11/7/18	103.3	8,016	85	70 - 100	9.2	7.3 – 16.4
Harietta	Michigan Dept. of Natural Resources	Eagle Lake Rainbow	61,248	0	1	9/22/18	9/24/18	10.4	5,889	91	91 - 91	15.8	15.8 – 15.8
Kettle Moraine	Wisconsin Dept. of Natural Resources	Skamania	72,837	0	2	10/11/18	10/12/18	8.9	8,193	101	101 - 101	10.3	10.1 – 10.5
Kettle Moraine	Wisconsin Dept. of Natural Resources	Chambers Creek	124,514	0	3	10/14/18	10/17/18	15.2	8,278	89	87 - 90	8.8	8.0 – 9.8
Kettle Moraine	Wisconsin Dept. of Natural Resources	Ganaraska	123,459	0	3	10/22/18	10/25/18	15.2	8,069	75	72 - 77	9.9	8.8 – 11.3
Lake Mills	Wisconsin Dept. of Natural Resources	Arlee Rainbow	105,225	0	2	6/5/18	6/6/18	16.4	6,478	90	88 - 92	10.4	9.7 – 11.1
	Steelhead totals and means:		**2,343,751**	**632,274**	**35**	**3/11/18**	**11/7/18**	**392.6**	**7,682**	**85**	**70 - 101**	**10.0**	**6.4 – 18.0**

Appendix III

Details of tagging and marking projects in 2018 for all other species

Hatchery	Agency	Species	Number tagged and clipped	Number clipped only	Number of tag codes	Start date	Complete date	Total machine run hours	Average fish/hour	Mean total length (mm)	Range of total length (mm)	Average coefficient of variation (CV)	Range of CV (mm)
Wild Rose	Wisconsin Dept. of Natural Resources	Brown trout	0	380,285	0	7/11/18	7/19/18	50.5	7,731	83	82 - 86	8.1	7.1 – 8.9
Platte River	Michigan Dept. of Natural Resources	Atlantic salmon	111,674	0	4	7/25/18	7/28/18	20.0	5,593	87	84 - 88	9.8	8.8 – 10.7
Iron River	U.S. Fish and Wildlife Service	Brook trout	75,030	0	-	9/12/18	9/14/18	14.9	5,036	101	101 - 101	12.4	12.4 – 12.4
Les Voight	Wisconsin Dept. of Natural Resources	Splake	0	73,107	0	7/28/18	7/30/18	14.9	4,907	105	105 - 105	10.6	10.6 – 10.6
Les Voight	Wisconsin Dept. of Natural Resources	Brown Trout	0	234,471	0	7/25/18	7/28/18	28.9	8,126	76	76 - 76	8.6	8.2 – 8.9
	Totals and means:		**186,704**	**687,863**	**4**	**7/11/18**	**9/14/18**	**129.2**	**6,950**	**85**	**76 - 105**	**9.0**	**7.1 – 12.4**

Appendix IV

Total fish processed for all tagging and marking projects 2010-2018

Species	Year									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	9-year total
Chinook Salmon	1,104,172	4,689,947	4,320,884	2,856,038	2,953,658	2,968,797	2,769,628	2,130,882	2,385,654	26,179,660
Lake Trout	4,584,509	5,779,176	6,094,302	5,660,034	6,297,988	6,389,825	4,916,035	3,789,570	3,675,933	47,238,052
Atlantic Salmon	0	0	97,804	133,706	154,182	190,170	96,308	169,829	111,674	953,673
Brook Trout	0	0	0	0	0	100,757	98,853	75,158	75,030	349,798
Brown Trout	0	0	0	0	0	0	327,615	472,439	614,756	1,414,810
Steelhead	0	0	0	0	0	0	0	2,797,781	2,914,609	5,712,390
Coho Salmon	0	0	0	0	0	0	0	61,117	0	61,117
Splake	0	0	0	0	0	0	0	70,197	73,107	143,304
Totals	5,688,681	10,469,123	10,512,990	8,649,778	9,405,828	9,649,549	8,208,439	9,566,973	9,850,763	82,002,124

Appendix V

Coded Wire Tags Extracted by USFWS 2010 –2018

	Species	2010	2011	2012	2013	2014	2015	2016	2017	2018	All Years
Lake Michigan	Atlantic salmon										-
	Chinook salmon	1	471	4,624	8,674	9,645	5,336	8,355	5,757	5,156	48,019
	Coho salmon			37	106						143
	Lake trout	1,081	471	494	937	2,094	4,106	6,026	5,524	6,217	26,950
	Steelhead			67	115	185	126	112	75	31	711
Lake Michigan totals		1,082	942	5,222	9,832	11,924	9,568	14,493	11,356	11,404	75,823
Lake Huron	Atlantic salmon						8	187	611	872	1,678
	Chinook salmon	1	1	444	1,226	1,648	1,434	1,933	1,921	1005	9,613
	Coho salmon										-
	Lake trout	3	105	180	94	118	369	469	479	497	2,314
	Steelhead			37	59	30	101	57	26	19	329
Lake Huron totals		4	106	661	1,379	1,796	1,912	2,646	3,037	2,393	13,934
Lake Ontario	Atlantic salmon										-
	Chinook salmon	787	1,687	3,358	3,535	2,546	1,833	1,659			15,405
	Coho salmon										-
	Lake trout	36	3	51	411	1,148	796	207			2,652
	Steelhead										-
Lake Ontario totals		823	1,690	3,409	3,946	3,694	2,629	1,866			18,057
Lake Erie	Atlantic salmon										-
	Chinook salmon										-
	Coho salmon										-
	Lake trout						2	1			3
	Steelhead										-
Lake Erie totals							2	1			3
All Lakes	Atlantic salmon	-	-	-	-	-	8	187	611	872	1,678
	Chinook salmon	789	2,159	8,426	13,435	13,839	8,603	11,947	7,678	6,161	73,037
	Coho salmon	-	-	37	106	-	-	-	-	-	143
	Lake trout	1,120	579	725	1,442	3,360	5,273	6,703	6,003	6,714	31,919
	Steelhead	-	-	104	174	215	227	169	101	50	1,040
	Unmerged in GLFSD	3	2	17	76	190	252	154	-	1	695
Total coded wire tags for year		**1,912**	**2,740**	**9,309**	**15,233**	**17,604**	**14,363**	**19,160**	**14,393**	**13,798**	**108,512**

✧

Tag/Data Field Recovery Program on Lakes Michigan & Huron, 2019(FWS)

***Fig 1: Map of statistical districts and offshore lake trout stocking locations in Lake Michigan and U.S. waters of Lake Huron*.**

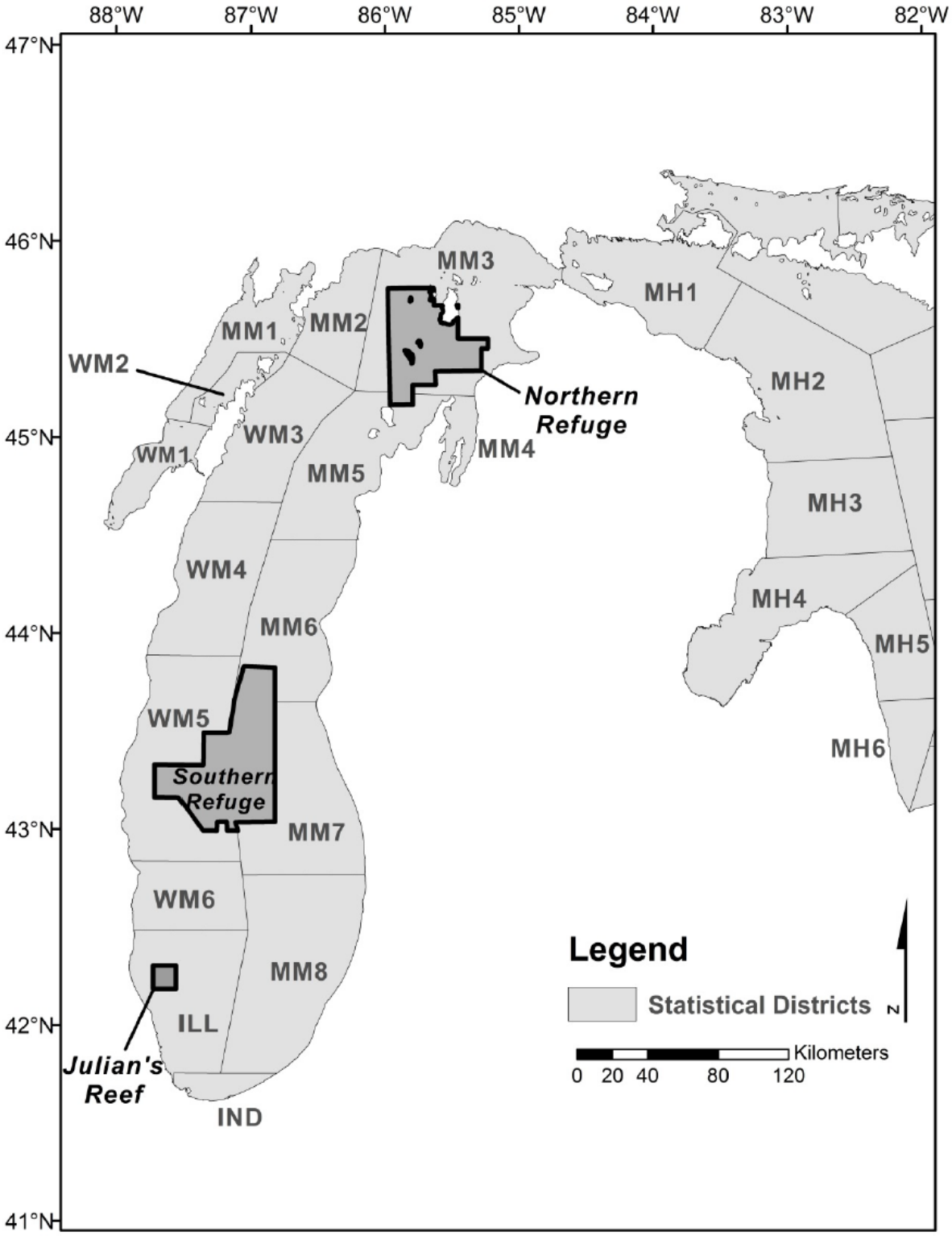


Table 1: Number of fish examined and number with fin clips and coded-wire tags (CWTs), by species, lake and year. All stocked Chinook salmon from the 2011 – 2016 year classes, and some from the 2017-18 year classes, received a fin clip and CWT. All stocked lake trout have received a rotated fin clip since the mid 1960's, and an adipose fin clip plus CWT since the 2010 year class. Steelhead have received an AD clip and CWT since the 2017 year class. Steelhead prior to 2017, and most brown trout and coho salmon, did not receive a fin clip or CWT; clips and tags for these species are from a handful of specific studies.

Species by recovery year	Lake Michigan			Lake Huron		
	Number examined	Number w/ fin clip	Number with CWT	Number examined	Number w/ fin clip	Number with CWT
Chinook salmon						
2012	9,922	1,776	1,712	240	49	48
2013	7,336	2,426	2,283	248	71	70
2014	12,170	4,657	4,448	277	119	117
2015	8,865	2,722	2,645	130	76	75
2016	7,354	2,666	2,549	95	59	58
2017	3,468	1,319	1,231	188	140	136
2018	4,422	1,509	1,131	155	44	36
Lake trout						
2012	512	463	196	426	289	39
2013	2,728	2,210	252	450	237	34
2014	3,781	3,169	415	621	309	89
2015	5,680	4,700	1,420	836	391	123
2016	5,547	4,694	2,400	803	387	110
2017	2,483	1,852	1,052	336	158	77
2018	3,636	2,616	1,052	865	313	148
Steelhead						
2012	114	56	47	139	19	10
2013	2,080	219	82	152	28	25
2014	2,733	359	144	94	19	18
2015	2,830	379	171	96	13	14
2016	2,762	349	124	78	15	13
2017	1,933	242	46	46	6	2
2018	1,613	195	28	47	5	2
Coho salmon						
2012	330	14	14	7	0	0
2013	3,417	49	37	29	0	0
2014	1,407	6	0	6	0	0
2015	2,155	2	0	42	0	0
2016	4,987	45	0	39	0	0
2017	1,665	24	1	13	2	2
2018	2,145	104	2	151	1	1
Brown trout						
2012	6	2	0	7	1	0
2013	425	30	1	10	0	0
2014	656	55	4	1	0	0
2015	532	85	2	1	0	0
2016	459	79	1	2	0	0
2017	304	85	0	6	6	0
2018	309	165	0	2	1	0
Atlantic salmon						
2012	0	0	0	9	4	0
2013	0	0	0	4	0	0
2014	1	1	0	31	29	1
2015	3	1	0	19	16	1
2016	1	1	0	28	27	15
2017	0	0	0	11	8	4
2018	3	2	2	50	39	26

Table 2: Percent of Chinook salmon examined by lab technicians during 2014 – 2018 that were wild (without a fin clip or CWT) by statistical district.

Sample sizes are in parentheses. Only fish from samples in which all Chinook salmon were examined are included; as a result, sample sizes for lakewide totals are less than reported in Table 1. Fish from all ages are included. Gray font indicates sample size < 20.

Statistical district	2014	2015	2016	2017	2018
Lake Michigan					
ILL	56.4 (928)	61.2 (273)	67.1 (566)	57.3 (253)	70.1 (87)
IND	65.6 (694)	65.5 (220)	69.1 (249)	54.5 (44)	65.1 (63)
MM1/ WM1	56.4 (117)	62.2 (246)	48.7 (232)	78.1 (32)	50.0 (2)
MM2	72.4 (134)	64.1 (64)	61.9 (84)	78.8 (80)	78.9 (19)
MM3	60.6 (33)	50 (2)	18.2 (11)	n/a (0)	75.0 (24)
MM4	66.7 (105)	66.7 (3)	50.0 (18)	42.9 (7)	72.7 (22)
MM5	80.8 (1037)	80.6 (325)	84.1 (132)	94.2 (137)	94.1 (68)
MM6	74.1 (1566)	79.7 (930)	82.3 (271)	82.2 (174)	79.9 (283)
MM7	62 (1355)	74.3 (672)	69.5 (308)	70.5 (44)	71.0 (100)
MM8	59.8 (962)	65.9 (355)	75.4 (57)	68.8 (109)	70.6 (228)
WM3	42.8 (514)	69.2 (916)	60.1 (430)	56.6 (113)	66.1 (189)
WM4	41.6 (1254)	67 (2659)	58.9 (1415)	59.9 (950)	66.1 (1437)
WM5	51.9 (1965)	65.7 (1597)	61.8 (1920)	52.7 (628)	66.0 (885)
WM6	54.8 (467)	51.5 (66)	65.8 (853)	59.3 (496)	52.9 (227)
L. Michigan	**59.8 (11131)**	**68.9 (8328)**	**63.5 (6546)**	**61.8 (3067)**	**67.5 (3634)**
Lake Huron					
MH1	48.7 (189)	25.7 (70)	22.2 (54)	16.8 (135)	59.2 (76)
MH2	100 (13)	100 (2)	83.3 (6)	68.4 (19)	80.0 (15)
MH3	60 (5)	100 (3)	66.7 (3)	n/a (0)	100 (2)
MH5	100 (9)	100 (8)	(0)	n/a (0)	80.0 (5)
MH6	100 (6)	100 (13)	85.7 (14)	n/a (0)	100.0 (12)
Lake Huron	**55.4 (222)**	**45.8 (96)**	**40.3 (77)**	**22.7 (154)**	**68.2 (110)**

Table 3: Number of stocked Chinook salmon smolts, and estimated number of wild Chinook salmon smolts, recruiting to the Lake Michigan population by year class.

Stocked values include a portion of the Chinook salmon stocked into Lake Huron based on recoveries of those fish in Lake Michigan during spring and summer (defined here as April – August) to feed. The number of wild smolts is calculated from the known number of stocked smolts and the percentage of wild Age-1 Chinook salmon from each year class. Estimates from the 2013 – 2017 year classes accounted for sampling and angler effort and were the average of statistical district-specific estimates of % wild at Age-1 (minimum of 10 fish recovered per district). Estimates from 2006 – 2012 year classes did not account for effort and were calculated from lakewide totals.

	Year class	No. stocked (millions)	Percent of fish stocked in L. Huron that were recovered in L. Michigan at age 1	Percent wild at age 1	Number wild (millions)	Total number smolts (millions)
OTC	2006	3.33		57.5	4.51	7.84
	2007	3.97	95	55.3	4.92	8.89
	2008	3.50	95	53.5	4.03	7.53
	2009	3.80	95	54.4	4.54	8.34
CWT	2010	4.08	95	63.0	6.94	11.02
	2011	3.93	95	54.0	4.62	8.55
	2012	3.87	95	63.8	6.82	10.68
	2013	2.38	90	38.6	1.50	3.88
	2014	2.45	96	59.8	3.65	6.10
	2015	2.45	95	48.6	2.32	4.77
	2016	2.35	94	64.3	4.20	6.55
	2017	2.29	94	60.4	3.47	5.76

Fig 2: Number of stocked Chinook salmon smolts (orange), and estimated number of wild Chinook salmon smolts (blue), recruiting to the Lake Michigan population by year class.

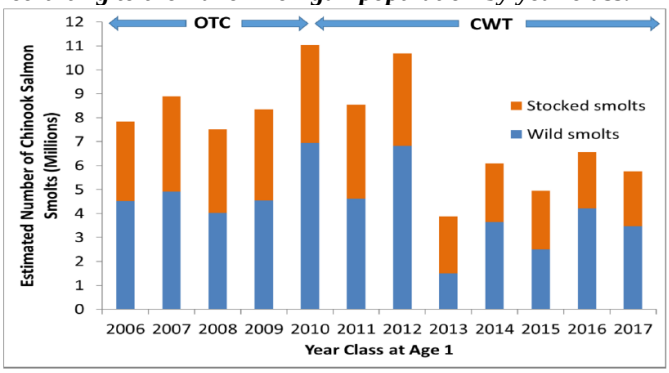


Table 4: Origin of Chinook salmon captured in Lake Michigan by recovery year.

Percentages of catch in Lake Michigan waters are corrected for angler and sampling effort and averaged across all recovery locations. Open-water catches of fish of all ages are included. Seasons include April – August, when Chinook salmon are likely engaged in foraging behavior, and September, when Chinook salmon are likely staging for autumn spawning runs. Numbers may not add to 100% due to rounding. These values represent the composition of each state's Lake Michigan fishery, but do not account for the number of fish stocked by each state and therefore should not be interpreted as patterns in survival.

	2014			2015		
Origin	Feeding (April – August)	Staging (September)	All months	Feeding (April – August)	Staging (September)	All months
Indiana	2.2	0.4	1.9	0.7	2.3	0.9
Illinois	2.8	3.7	2.9	2.0	0.4	1.7
Michigan	8.6	9.1	8.6	5.1	2.7	4.7
Wisconsin	15.5	29.7	17.2	14.4	47.8	19.9
Lake Huron (MI)	8.6	3.2	8.0	10.3	5.6	9.5
Wild	62.4	53.9	61.4	67.5	41.0	63.2

Table 7: Percent of total catch of Lake Trout stocked at offshore and nearshore locations, broken up by origin. Percentages are based on raw catch values (i.e., not corrected for number of fish stocked) and represent the contribution of Lake Trout by source to angler creels (n = sample size). This answers the question "Where were Lake Trout caught by anglers stocked?" Recoveries were from 2012-2018, but primarily from 2015 – 2018. Of the offshore stocking locations, fish stocked in the Southern Refuge had the most consistent contribution to state anglers' catch. Julian's Reef contributed substantially to Illinois, Indiana and Wisconsin waters, but less to Michigan waters. Northern refuge fish contributed <10% to catch in all state waters except Wisconsin. Nearshore stocking is heaviest in Michigan waters, so it comes as no surprise that Michigan waters had the highest percentage of nearshore fish in the creel (45%).

Recovery area	Percent Offshore				Percent nearshore	n
	Julian's Reef	Southern Refuge	Northern Refuge	Total % offshore		
Lake Michigan	20	39	7	66	34	5,671
Wisconsin Waters	21	55	14	90	10	922
Illinois Waters	45	50	1	96	4	313
Indiana Waters	36	38	0[1]	74	26	1,502
Michigan Waters	8	33	9	50	49	2,935

✧

2018 August Asian Carp Monitoring

Summary

Below is the August 2018 Asian Carp monthly summary from the crew working the Chicago Waterway System (CAWS). The goal of the summary is to provide up-to-date information on the monitoring and research projects outlined in the 2017 MRP and additional relevant Asian carp developments.

Bottom Line: Monitoring occurred in the CAWS and upper Illinois Waterway upstream and downstream of the Electric Dispersal Barrier in March. **NO LIVE BIGHEAD CARP OR SILVER CARP** were found in any new locations immediately downstream of the Electric Dispersal Barrier.

Fixed, Random and Targeted Site Sampling Downstream of the Electric Dispersal Barrier

Electrofishing:

• Crews from IDNR completed 24 electrofishing runs at fixed and random sites (6 hours total) in Dresden Island Pool and Marseilles Pool during August.
• They collected 1,460 fish representing 40 species and 1 hybrid group.
• No Asian carp were captured or observed in the Marseilles Pool or Dresden Island Pool during electrofishing.

Hoop and Mini Fyke Netting:

• Crews from IDNR set and pulled 16 hoop nets and 16 mini fykes from fixed sites in Lockport, Brandon Road, Dresden Island and Marseilles Pools in July.
• Crews collected 44 fish representing 9 species during hoop net sampling and 689 fish representing 25 species and 1 hybrid group during mini fyke sampling.
• One Bighead Carp was collected above I-55 in Dresden Island during hoop net sampling.
• Two Silver Carp were collected during hoop net sampling in the Marseilles Pool.
• No Bighead or Silver Carp were reported, captured or observed during hoop net sampling in the Lockport or Brandon Road.
• No Bighead Carp or Silver Carp were reported, captured or observed during mini fyke sampling in any of the pools.

Commercial Netting:

• Contracted commercial fishers along with assisting IDNR biologists set 16.5 miles of gill net at fixed and targeted sites in the Lockport, Brandon Rd and Dresden Island Pools (including Rock Run Rookery) in July.
• They collected 1033 fish representing 14 species and 1 hybrid group.
• Six Bighead Carp and 63 Silver Carp were collected in Dresden Island Pool, downstream of I-55.
• No Bighead Carp or Silver Carp were collected above I-55 in Dresden Island during commercial netting
• No Bighead Carp or Silver Carp were captured or observed in Lockport or Brandon Road Pools.

Sampling results by pool below the electric dispersal barrier through August 2018, along with the same time period in 2016 and 2017 for comparison:

Lockport			
	2016	2017	2018
Yards of Net Fished	68,200	62,600	62,500
Miles of Net Fished	38.7	35.6	35.5
Hoop Net Nights	38.4	32.6	32.6
Mini Fyke Net Nights	18.8	17.7	16.9
Electrofishing Runs	83	92	27
Electrofishing Time (hrs)	20.8	23.0	6.8
Total Asian Carp (AC)	0	0	0
Tons of AC Harvested	0	0	0

Brandon Rd			
	2016	2017	2018
Yards of Net Fished	63,850	70,200	63,000
Miles of Net Fished	32850.0	39.9	35.8
Hoop Net Nights	38.6	35.4	31.1
Mini Fyke Net Nights	19.0	19.6	14.7
Electrofishing Runs	91	95	24
Electrofishing Time (hrs)	22.8	23.8	6.0
Total Asian Carp (AC)	0	0	0
Tons of AC Harvested	0	0	0

Dresden Island			
	2016	2017	2018
Yards of Net Fished	59,900	72,300	133,300
Miles of Net Fished	34.0	41.1	75.7
Hoop Net Nights	39.1	327.4	28.3
Mini Fyke Net Nights	20.7	23.0	15.7
Electrofishing Runs	172	156	105
Electrofishing Time (hrs)	43.0	39.0	26.3
Asian Carp (AC) upstream I-55	11	27	4
AC downstream I-55	261	547	966
Total AC	272	574	970
Tons of AC Harvested	1.9	4.5	7.7
AC/1000 yds of gill net	4.0	7.6	7.3

Rock Run Rookery			
	2016	2017	2018
Yards of Net Fished	32,250	27,850	29,400
Miles of Net Fished	18.3	15.8	16.7
Pound Net nights	0	0	4
Bighead Carp	122	186	59
Silver Carp	29	35	50
Total Asian Carp (AC)	151	221	109
Tons of AC Harvested	2.4	3.6	1.5
AC/1000 yds of gill net	4.7	7.9	3.7

USACE Fixed, Random, and Targeted Site Sampling Downstream of the Electric Dispersal Barrier

During the month of August 2018 USACE crews conducted boat mounted electrofishing surveys in the Lower Lockport, Brandon Road, and Dresden Island pools. Six hours of electrofishing were conducted in Lower Lockport, six in Brandon Rd, and two in Dresden Island. A total of 4228 fish were caught during this time period across the three pools. Gizzard shad under six inches made up 73.2% of the catch, 7.7% was Emerald shiner, 4.2% Threadfin shad, 3.4% Gizzard shad over six inches, 2.5% Largemouth bass, and 1.4% of the catch was Common carp. There were 2 Silver carp captured in the Dresden Island pool with an additional 10 being observed. No Asian Carp were observed in the Lower Lockport or Brandon Rd pools. A total 263 non-native fish were collected, encompassing seven species. All records of non-native species were recorded and submitted to the Nonindigenous Aquatic Species database.

Asian Carp Removal Project

Removal takes place specifically in the Marseilles and Starved Rock Pools. Below is a summary of all IDNR Barrier Defense activities through July 2018, along with the same time period in 2016 and 2017 for comparison:

	2016	2017	2018
Number of Days Fished	65	55	61
Number of Net Crew Days	406	319	313
Yards of Net Fished	356,995	284,910	253,900
Miles of Nets Fished	202.8	161.9	144.3
Number of Pound Net Nights	67	74	21
Number of Hoop Net Nights	768.7	879.8	1217.1
Number of Bighead Carp	6,535	2,587	2,718
Number of Silver Carp	79,792	84,859	79,703
Number of Grass Carp	453	674	783
Number of Asian Carp (AC)	86,780	88,120	83,204
Tons of AC Harvested	310.1	307.6	307.9
AC/1000 yds of gill net	228.3	259.6	310.1

Marseilles			
	2016	2017	2018
Yards of Net Fished	263,275	189,410	118,300
Miles of Nets Fished	149.6	107.6	67.2
Pound Net nights	20	35	15
Hoop Net nights	121.6	80.7	255.5
Mini Fyke Net Nights	18.0	19.4	15.7
Electrofishing Runs	116	100	97
Electrofishing Time (hrs)	29.0	25.0	24.3
Bighead Carp	4,633	1,401	1,291
Silver Carp	37,237	29,726	26,216
Grass Carp	85	56	34
Total Asian Carp	41,955	31,183	27,541
Tons of AC Harvested	183.1	135.3	131.0
AC/1000 yds of gill net	153.9	159.3	231.1

Starved Rock			
	2016	2017	2018
Yards of Net Fished	93,720	95,500	135,600
Miles of Nets Fished	53.2	54.3	77.0
Hoop Net nights	683.1	831.2	992.6
Bighead Carp	1,911	1,194	1,428
Silver Carp	43,427	55,563	53,562
Grass Carp	399	635	757
Total Asian Carp	45,737	57,392	55,747
Tons of AC Harvested	130.5	174.1	177.2
AC/1000 yds of gill net	437.2	458.5	379.0

Barrier Defense Using Novel Gear

During August 7-9 and 28-30, 2018, staff from the USFWS collaborated with the Illinois DNR' barrier defense project to remove Asian carp from the Starved Rock Pool of the Illinois River using an electrified paupier. An estimated total of 14,403 Silver Carp (approximately 85,803 lbs or 42.9 tons) were removed in 15.1 hours of electrotrawling over the two weeks (Table 1). The estimated total number and weight were calculated from a daily 10% subsample of fish that was taken during offloading. The paupier captured Silver Carp at a rate of 955/electro-trawling hour. Total time spent on the water and crew size are used to assess efficiency. Bycatch (species other than Asian carp) was approximately 12% of the fish captured, 3% of the biomass captured, and dominated by Smallmouth Buffalo and Gizzard Shad. The last mass removal effort of the year is planned for mid-late September, 2018.

	Monthly Total
Number of Days on Water	6
Hours on Water	48.6
Crew Size	11
Electrotrawling Hours	15.1
Silver Carp Count	14,403
Bighead Carp Count	0
Grass Carp Count	4
Silver Carp Biomass (lbs)	85,803
CPUE (Silver Carp Biomass/Labor Hour)	160
CPUE (Silver Carp Biomass/Electrotrawling Hour)	5,682
CPUE (Silver Carp Count/Electrotrawling Hour)	954
Bycatch: % of fish NOT Asian carp by count	12%
Bycatch: % of fish NOT Asian carp by weight	3%

Table 1. ***Summary of USFWS effort with the paupier and fish capture information for barrier defense in Starved Rock Pool, August 7-9 and 28-30, 2018.***

Distribution and Monitoring of Juvenile Asian carp

Field crews sampled Marseilles, Starved Rock, and the upper part of Peoria pool for small Silver and Bighead carps (TL <153mm) during August 2018. In Marseilles, effort totaled 22 sites (3.5 hrs fishing time) and resulted in 2,570 fish captured representing 43 species. A sum of 18 adult Silver Carp were captured and eliminated. In the Starved Rock Pool, the electrified dozer trawl was used alongside boat electrofishing for a total of 12 sites (2 hrs fishing time) over two days. This sampling resulted in 923 fish captured representing 26 species. A total of 64 adult Silver Carp and 1 Bighead Carp were captured and destroyed. Efforts in Peoria were focused on the upstream most section below the Starved Rock Dam and in the Vermillion River. The dozer trawl was used for a total of 8 sites (40 minutes fishing time) and boat electrofishing for 3 sites (45 minutes fishing time). A total of 332 fish were captured, representing 22 species, 109 of which were adult Silver Carp. No juvenile Silver or Bighead Carp were collected as a result of this sampling.

Habitat Use and Movement of Juvenile Silver Carp (Telemetry)

Two large tagging events took place during August primarily to tag fish for the SEAcarP model support. During this effort, 110 Silver Carp greater than 350mm (SEAcarP model support) and 8 Silver Carp less than 350mm TL (Habitat Use and Movement of Juvenile Silver Carp) were tagged. Efforts to collect fish totaled 9 dozer trawl runs (45 minutes fishing time) and 14 boat electrofishing runs (2.5 hrs fishing time). Additionally, all telemetry receivers were downloaded and mounting hardware replaced where necessary.

Telemetry

There was no field activity taken in the month of August supporting the USACE Telemetry monitoring project. Downloads of stationary receivers are conducted every other month. The next download is scheduled for the week of 10 September.

Fish Suppression for Barrier Maintenance

The Barrier IIA narrow array experienced a minor loss of power to the water (<1 minute) on 7 August. On the night of 9-10 August the Barrier IIA experienced 8 outages of 7-9 minutes each. At 1:00 on 10 August the IIA narrow array was powered down by Barrier operations staff to limit damage to the equipment. Troubleshooting then occurred at Barrier IIA narrow array through the following week and a half with the narrow array on parts of the day on Aug 10, 13, 15, 17, and 20; all day on Aug 16, 18, and 19; and not operational at all on Aug 11, 12, and 14. The Barrier IIA wide and narrow arrays were powered down between 8:17 and 13:03 for repair work on 20 August after which both arrays were brought back online and ran continuously for the remainder of the month. The Barrier IIA wide array was operational for the entire month except the repair period on 20 August. The Barrier IIB wide and narrow arrays remained operational for the entire month of August. The Demonstration Barrier was powered off for 10 minutes on the early afternoon of 16 August for an inspection needed to plan for electrode replacement this winter. Otherwise the Demonstration Barrier was operational for the full month.

A notification of the primary barrier outages (Barrier IIA) was provided to the MRWG for consideration of relative risk and response actions. Planned monitoring including electrofishing, netting, and sonar surveys in the area continued as scheduled and helped informed the MRWG with recent data on fishes in the area. USACE performed an electrofishing survey between Barriers IIA and IIB on 29 August 2018 resulting in 30 Gizzard Shad, 1 small Salmonidae, and 1 Emerald Shiner all under 12 inches in total length. No large fishes over 12 inches in total length were observed and no Asian carp were captured or observed upstream of the Brandon Road Lock and Dam.

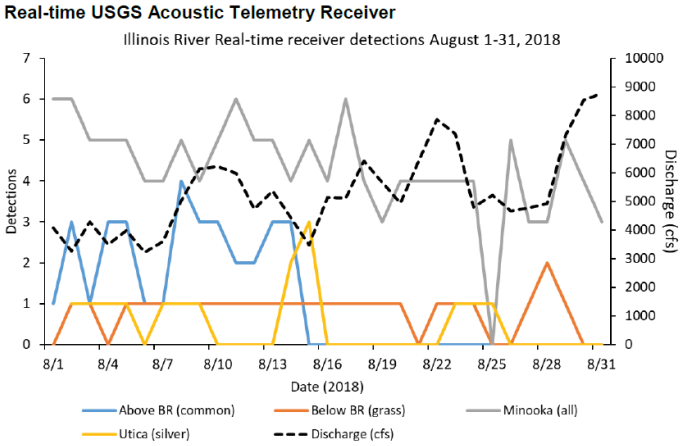


Fig 1. Fish detectgions for 1 August – 31 August at Utica, Minooka, and Rockdale (above Brandon Road and below Brandon Road) receivers.

All fish shown for Utica (RM 229; yellow) are silver carp. Fish detected at Minooka (RM 271; gray) include bighead, silver and one grass carp. At Rockdale below Brandon Road (RM286; orange) all fish are grass carp and above Brandon Road (RM287; blue) all fish are common carp. Discharge for the Marseilles gaging station (USGS 05543500) is shown as a black dotted line.

Seventeen Bighead or Silver Carp were detected on real-time receivers from 1 August – 31 August 2018. All Bighead and Silver were detected at Utica (N = 6 Silver Carp) or at Minooka above Dresden Island Lock and Dam (N = 9 Bighead Carp, 2 Silver Carp). Additional common or grass carp were detected at the Rockdale receiver below Brandon Road Lock and Dam (N = 2 Grass Carp), at Rockdale above Brandon Road Lock and Dam (N = 4 Common Carp), and at Minooka (N = 1 Grass Carp). For additional details, please refer to the attached spreadsheet and graphs. For questions, please contact Marybeth Brey (mbrey@usgs.gov).

Ecosystem Response to Asian Carp Barrier Defense and Removal

INHS collected zooplankton and water chemistry samples at 15 main channel and backwater sites located in the Brandon Road, Dresden Island, Marseilles, Starved Rock, Peoria, LaGrange, and Alton Pools during the weeks of June 4 and June 18. The collected data will be compared to previous years' data from the same locations and will be used to assess changes in zooplankton densities and community composition in response to changing Asian carp densities.

Larval Fish Monitoring

INHS conducted ichthyoplankton sampling at 12 main channel and backwater sites located in the Brandon Road, Dresden Island, Marseilles, Starved Rock, Peoria, and LaGrange Pools during the weeks of August 6 and August 20. Four larval fish samples were collected at each site. Additional samples were collected in Illinois River tributaries to evaluate the potential for Asian carp spawning in these rivers. Processing and analysis of all samples is ongoing, and more detailed results will be reported once available. Ichthyoplankton sampling will continue on a biweekly basis through October.

Ecosystem Response to Asian Carp Barrier Defense and Removal

INHS collected zooplankton and water chemistry samples at 15 main channel and backwater sites located in the Brandon Road, Dresden Island, Marseilles, Starved Rock, Peoria, LaGrange, and Alton Pools during the weeks of August 6 and August 20. The collected data will be compared to previous years' data from the same locations and will be used to assess changes in zooplankton densities and community composition in response to changing Asian carp densities.

Using Long-term Asian Carp Abundance and Movement Data to Reduce Uncertainty of Management Decisions

Asian carp densities were estimated from mobile hydroacoustic surveys conducted in late July 2018 in the Dresden Island and Marseilles pools. Water depths during sampling were relatively low. Asian carp (Bighead Carp and Silver Carp combined) densities in Dresden Island pool were highest in the nearshore areas near the mouth of the Kankakee River (Figure 1). Densities throughout the rest of Dresden Island Pool were low in comparison. July Asian carp densities in the Marseilles Pool were relatively low in the main channel, where densities were highest in the stretch downstream from the entrance to the HMS East Pit (Figure 2). Densities were relatively high throughout much of the East Pit, particularly near shore in the northeast embayment and the western end. Asian carp densities in the West Pit were highest in the western end and surrounding the island in the eastern portion of the lake.

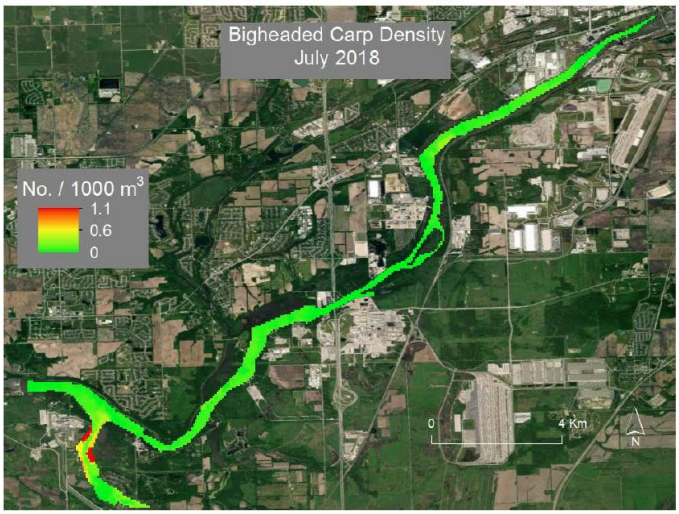


Fig 1. Bighead Carp and Silver Carp densities in the Dresden Island Pool from mobile hydroacoustic surveys conducted in July 2018.

Alternate Pathway Surveillance in Illinois - Law Enforcement

ISU interviewed the owners of two aquaculture facilities that raise black carp and obtained records from those businesses while continuing to investigate how triploid black carp were introduced into Horseshoe Lake. ISU identified an individual who placed an advertisement offering to sell crappie he had caught while recreationally fishing. ISU followed up on a complaint of two out of state individuals illegally harvesting crayfish and offering to sell them alive in Illinois. ISU issued a written warning to a Chicago aquaculture facility raising tilapia with an expired permit. ISU is preparing a search warrant for cellular records and obtaining court orders for other documents as evidence against a Kentucky resident for fraudulently obtaining licenses and permits from the IDNR.✧