Yellowstone Center for Resources
National Park Service
Department of the Interior

Native Fish Conservation Program Report

2022

Student Conservation Association Fisheries Intern Bonnie Dana with a large cutthroat trout on upper Slough Creek NPS Photo.

Background

Yellowstone National Park supports some of the most pristine aquatic ecosystems on Earth. The high plateau upon which Yellowstone lies includes the Continental Divide between drainages of the Pacific and Atlantic oceans. From the park emerge streams that join to become three of America's most important waterways: the Yellowstone, the Missouri and the Snake rivers. At the heart of the park lies Yellowstone Lake. At an altitude of 7,730 feet, surface area of 136 square miles, and depth up to 400 feet, the lake is the largest alpine body of water in North America.

About five percent of the park is covered by water, including more than 220 lakes and 2,650 miles of streams. These waters support 12 species or subspecies of native fish, including popular sport fish such as Arctic grayling, mountain whitefish, westslope cutthroat trout, and Yellowstone cutthroat trout.

Prior to establishment of Yellowstone in 1872, about 40% of park waters were barren of fish because natural waterfalls and watershed divides blocked access following glacial recession. Between 1889 and the mid-1950s more than 300 million fish were stocked by managers to park waters, including waters that supported native fish, which led to extensive establishment of non-native populations. Initially, the adverse effects of non-natives were not known. However, in the decades following these introductions, non-native brook, brown, rainbow, and lake trout had significant detrimental effects on native fish through hybridization, predation, and displacement.

Yellowstone's native fish support natural food webs, contribute significantly to the local economy, and provide unparalleled visitor experiences. As a result, the National Park Service (NPS) has undertaken actions to reverse decreasing trends in native fish populations and associated losses of ecosystem function. A Native Fish Conservation Plan (https://parkplanning.nps.gov/projectHome.cfm?projectID=30504), completed in December 2010, continues to be implemented with the goal of restoring the ecological roles of native species while ensuring sustainable angling and viewing opportunities for visitors (Figure 1.)

This report documents the conservation actions, long-term monitoring, and assessments made to conserve Yellowstone's native fish by the NPS and its collaborators during 2022. This and previous annual reports are available in electronic format at the Yellowstone National Park website (http://www.nps.gov/yell/planyourvisit/fishreports.htm).

ACTIONS TO RESTORE YELLOWSTONE LAKE

Nonnative predatory lake trout were intentionally stocked by the U.S. Fish Commission in 1890 to historically-fishless Lewis and Shoshone lakes in the upper Snake River drainage of Yellowstone National Park. During the century that followed, lake trout became established in Yellowstone Lake and were first detected there in 1994. Because lake trout pose serious threats to the native cutthroat trout population and the natural ecology of Yellowstone Lake, the population has been suppressed by gillnetting since 1995. Over the past 27 years more than 4.3 million lake trout have been gillnetted. Suppression actions that complement gillnetting have also been developed and implemented. These actions include tagging and telemetry of adults to locate movement corridors and congregations of fish, and treatments of spawning sites with organic material to kill embryos and fry during autumn.

Lake Trout Suppression Netting

Yellowstone Lake became ice free to begin gillnetting on June 5, 2022, about two weeks later than normal, and gillnetting continued until mid-October. A total of seven specialized boats were used for gillnetting including the contractor-owned boats Kokanee, Patriot, Northwester, and Stuth Bros. and the NPS boats Cutthroat, Freedom, and Hammerhead. Experienced gillnetting crews processed 89,320 units of gillnet effort in 2022 surpassing effort benchmarks set by population modeling. Each day during the gillnetting season, approximately 40 miles of gillnet were fishing for lake trout. Gillnets totaling more than 5,500 miles in length, nearly one-fourth the circumference of the earth, were set and lifted from the lake in 2022.

During 2022, gill nets were distributed across most of the lake, fishing areas less than 200 feet deep, the depths that have proven to be most productive (Figure 2). Proportionally, effort continued to be focused on the West Thumb, Breeze Channel, and Main Basin regions near Frank Island where catches remain the highest. Although all size classes of lake trout were targeted, slightly more effort continued to be focused on removal of large, adult lake trout. The suppression effort removed 281,500 lake trout in 2022 with an overall (all mesh sizes) catch-per-unit-effort (CPUE; catch per 100 meters of gillnet per night) of 3.1; 5.3 for the smaller meshes and 1.2 for the larger meshes (Figure 3).

Lake Trout Population Modeling

Total abundance of age-2 and older lake trout were estimated using a statistical catch-at-age model by research collaborators at Michigan State University. Using catch data through 2022, the current estimates were developed in spring 2023. Estimated total abundance of lake trout at the beginning of 2022 was 651,103 (509,239 – 792,960; 95% CI) fish, which was an approximate 9% decrease from the abundance at the beginning of the previous year 2021. Approximately 57% of the 2022 lake trout abundance at the beginning of the year was composed of age-2 (i.e., newly recruiting fish). Abundance of age-3 to age-5

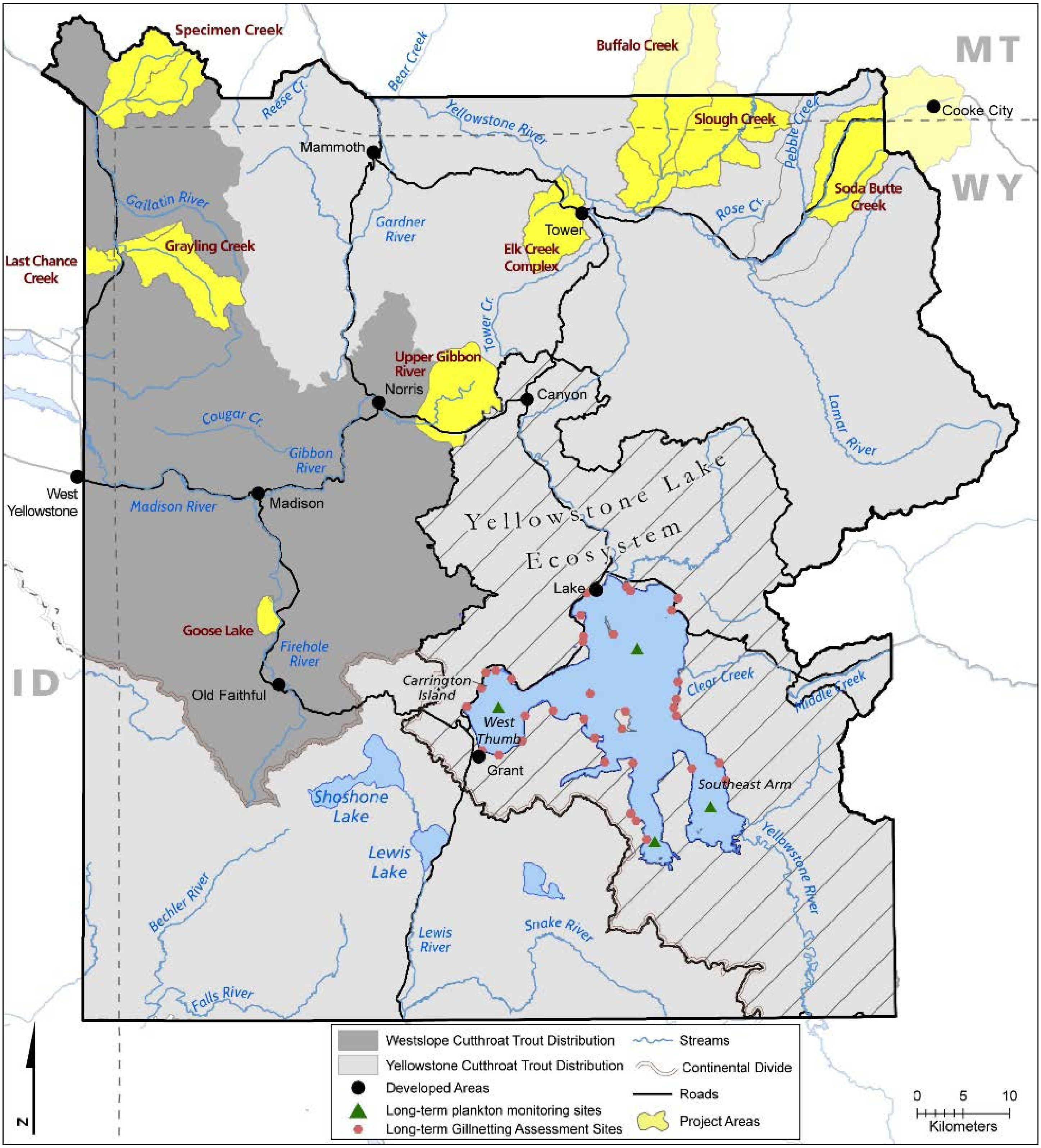


Figure 1. Yellowstone National Park with watersheds supporting native Arctic grayling and westslope cutthroat trout (dark gray, Gallatin and Madison watersheds) and Yellowstone cutthroat trout (light gray, Snake and Yellowstone). Native fish conservation project areas outside of Yellowstone Lake are highlighted in yellow.

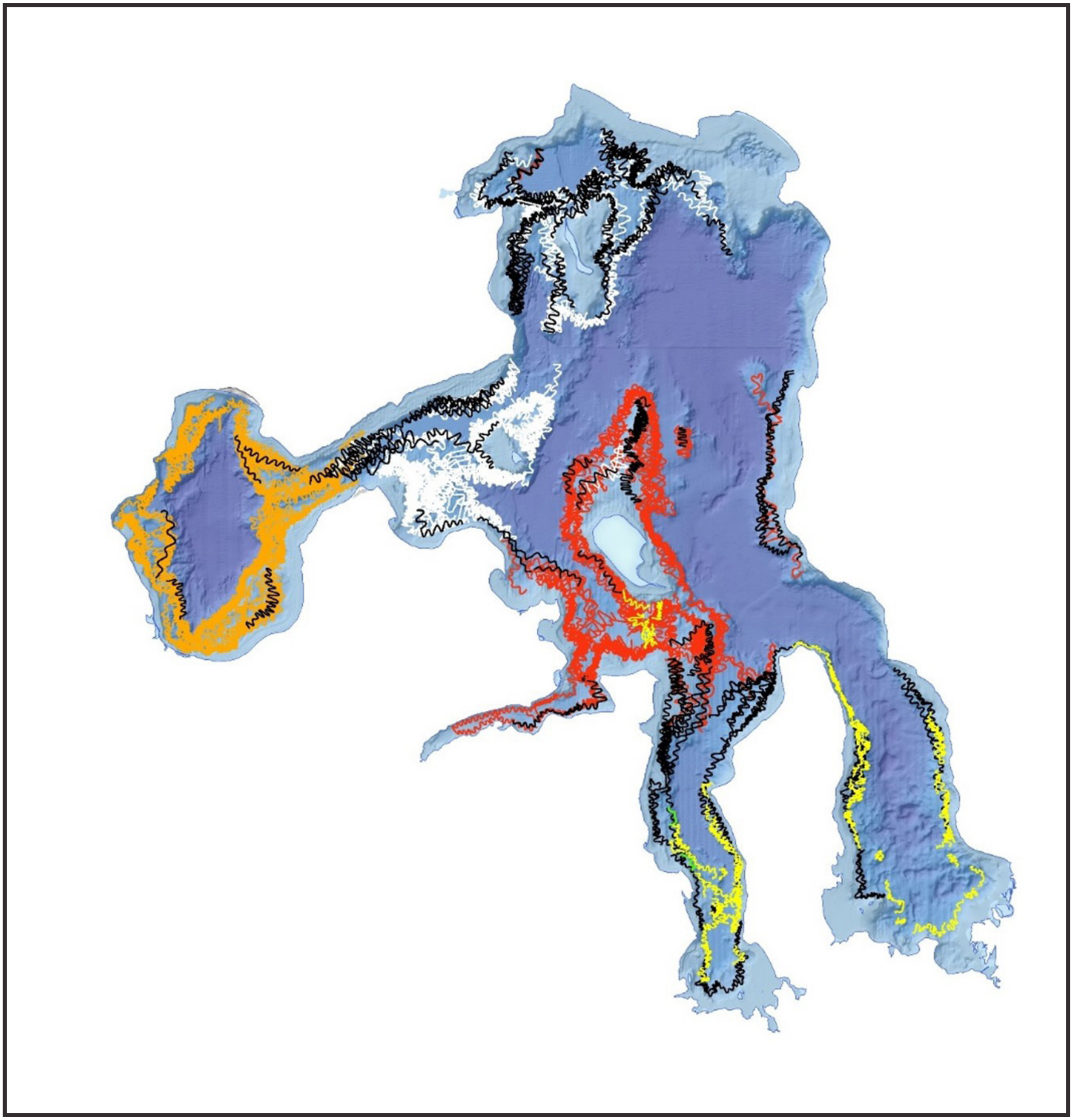


Figure 2. Locations of gillnets set to capture lake trout June – October 2022. Colors represent sets by specific boats throughout the season.

lake trout increased in 2022 due to higher recruitment over the last couple of years, however, the abundance of age-6 and older lake trout continued to decrease (Figure 4).

The sustained gillnetting efforts have caused an 92% decline in estimated abundance of older (age-6+) lake trout, from about 53,400 fish in 2012 to only 4,000 in 2022. As a result, the larger, older lake trout have become more difficult to catch by gillnetters. However, the lake trout population is demonstrating resilience, necessitating continued high levels of gillnetting suppression for at least several more years to ensure the newly recruiting lake trout do not reach maturity and the long-term population decline will continue.

Fisheries Biologist Philip Doepke leading gillnetting crews on the NPS boat Hammerhead.

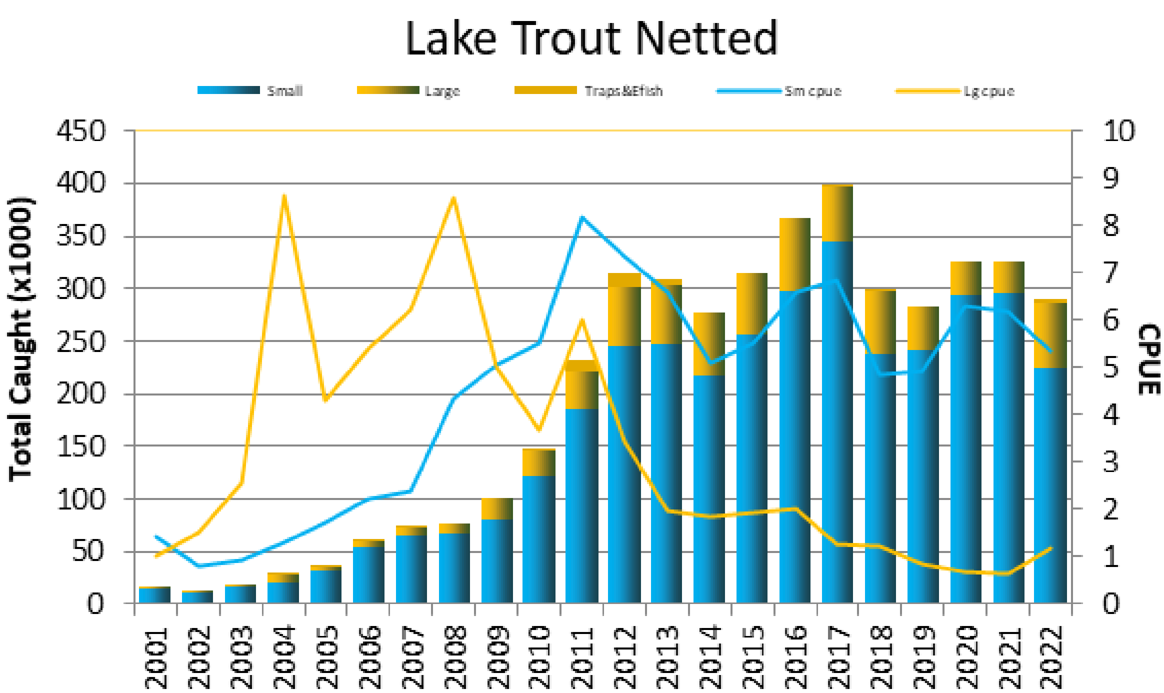


Figure 3. Number of lake trout gillnetted (bars) and catch-per-unit of effort (lines) during 2001-2022. Blue represents the smaller mesh sizes (1 to 1.5-inch bar) which tend to catch juveniles, and gold represents the larger mesh sizes (1.75 to 2.5-inch) which tend to catch adults.

YELLOWSTONE LAKE RESEARCH

Lake Trout Acoustic Telemetry

Since 2011, acoustic telemetry has been used to learn more about lake trout movements and use of spawning areas in Yellowstone Lake. This information has been helpful in targeting adult lake trout for removal, especially when adults gather in autumn for spawning. During 2022, 207 adult lake trout were surgically implanted with acoustic transmitters. In addition, about 100 lake trout with active acoustic tags from previous years remained in the lake. Lake trout habitat across Yellowstone Lake was searched 2 to 3 times per week during peak spawning activities from mid-September through early October. Tracking of lake trout using boat-mounted acoustic receivers relocated 263 of them in 2022 at least once, with a few located 10 or more times each. This information was relayed to gill netting crews so they could target fish aggregations with gillnets. Summaries of telemetry data are also used to predict where new, previously unknown spawning sites may be located.

Lake Trout Reproductive Potential

We sought evidence for reproductive compensation following more than a decade of intensified suppression gillnetting and a concurrent 86% decline in adult lake trout (2011-2022). Gonadal tissue was collected from 262 adults (less than 300 to more than 800 millimeters [mm] total length) to determine stages of maturity among seven 100-mm size classes, and to estimate the proportion of the population that spawns annually. Gonadal tissue was also collected from 126 mature females to investigate fecundity. Results of this study will be compared to other reproductive studies conducted prior to the decline in adult lake trout to quantify possible changes in their reproduction potential through time. Results may be used to refine benchmarks for gillnetting effort and long-term goals for lake trout population abundance.

Lake Trout Embryo Suppression

Over the last several years suppression methods that cause lake trout embryo mortality have been evaluated with an overall goal of finding methods that could effectively complement gillnetting in an Integrated Pest Management (IPM) approach to suppress the lake trout population. Organic pellets made of soy and wheat gluten placed on spawning substrates after the lake trout had spawned was the most effective method. We completed large-scale experimental pellet treatments followed by evaluations of fry production at the Carrington Island spawning reef, 2019 – 2022. Our results indicated that organic pellet treatments can be used to cause high mortality of lake trout embryos, without deterring adults from spawning in years following the treatments. In the future we may continue treatments of Carrington Island and potentially other suitable sites as a method to complement gillnetting.spawning areas on Yellowstone Lake.

Lake Trout Pre-Recruit Dynamics

Stock-recruitment models suggest that pre-recruit (age-0 and age-1) lake trout survival is 4–6 times higher in Yellowstone Lake than in the species native range. Lake trout embryos and fry experience little predation in Yellowstone Lake, and ongoing suppression gill netting does not catch lake trout until they recruit to nets at age-2. Statistical catch-at-age models indicate that the juvenile lake trout abundance has not declined under the current suppression program. Ongoing research is being conducted to better understand juvenile lake trout population metrics such as hatch dates, habitat use, relative abundance, age, growth, and diet shifts among spawning sites and non-spawning sites in Yellowstone Lake. The study will result in an improved understanding of factors affecting lake trout recruitment success, and potential ways it might be curtailed.

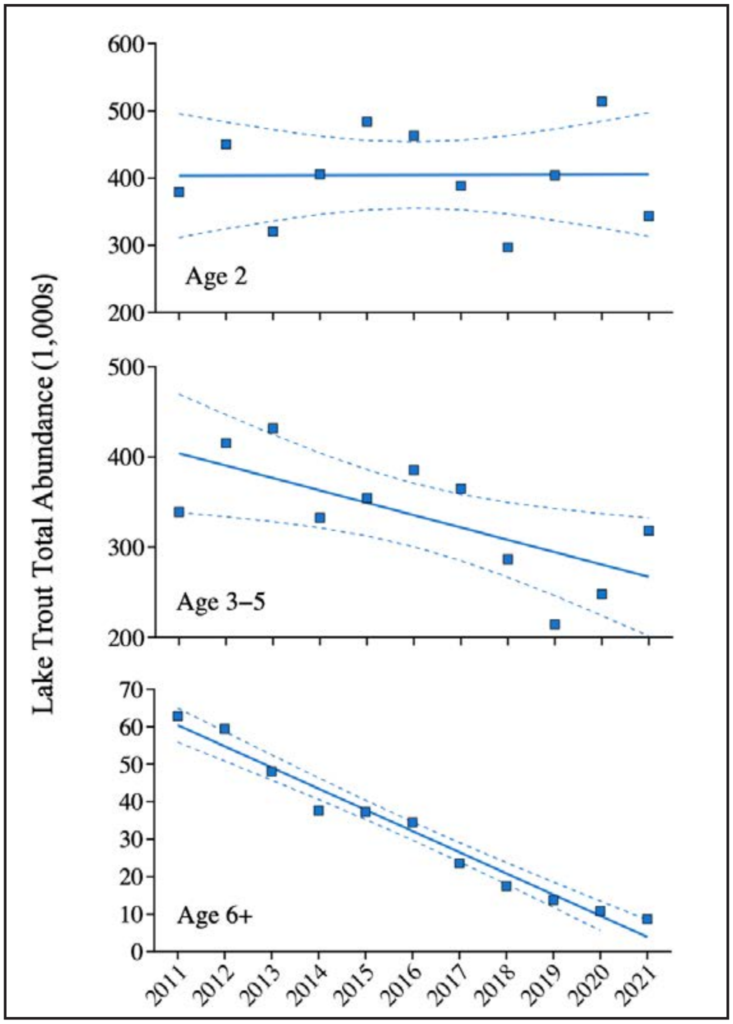


Figure 4. Abundances of age-2, age-3 to age-5, and age-6+ lake trout at the start of the year from 2011 through 2021 estimated using a statistical catch-at-age (SCAA) model. Blue lines represent simple linear regression models with 95% confidence intervals (dashed lines). There was no decline in age-2 abundance. Age-3 to age-5 abundance and age-6+ abundance declined significantly.

Research is being conducted to better understand juvenile lake trout population dynamics in Yellowstone Lake.

Cutthroat Trout Population Size Estimate

During 2022, contract netters used 8 large trap nets to capture cutthroat trout and lake trout and hold them alive, thereby providing a means to collect them in shallow, near-shore areas where both species are found. Trap nets were placed in all lake regions except the Southeast Arm and lifted and checked 1-5 times per week during mid-July through late-August. A total of 2967 trap-netted cutthroat trout were sorted from the lake trout and tagged using external, colored latex (Floy) tags by research collaborators from Montana State University. Each tag had a unique digit fish identification number and a phone number for anglers to call and report when caught. A total of 256 tagged cutthroat trout were recaptured by gill nets (9%), 181 by trap nets (6%), and 10 (0.3%) by anglers in 2022. The recaptures of tagged fish will be used to estimate the total abundance of large (greater than 400 mm) cutthroat trout in Yellowstone Lake. In addition, adult lake trout captured by the trap nets were surgically implanted with acoustic transmitters for telemetry studies (described above) or sampled for other on-going studies. All other lake trout were killed and deposited in deep areas of the lake.

YELLOWSTONE LAKE MONITORING

Gillnetting Assessment of Cutthroat and Lake Trout

Since 2011, cutthroat trout and lake trout in Yellowstone Lake are monitored annually during August by standardized lake-wide gillnetting at 24 sites located around the lake (Figure 1) to assess the relative abundance and size structure of both species. The assessment gillnets have a range of mesh sizes to capture fish in multiple size classes within three depth strata (shallow, mid-water, and deep). The average number of cutthroat trout caught in 100 meters of net per night (CPUE; shallow strata only) in 2022 was 7.79 (6.14 – 9.43; 95% CI), continuing a slight increasing trend since 2011. Between 2011 and 2022, the CPUE ranged from 4.23 (2.82 – 5.64; 95% CI) to 11.87 (10.37 – 13.36). Cutthroat trout size structure has stayed relatively constant since 2019 with most of the catch greater than 400 mm length (Figure 6).

Prior to 2011, cutthroat trout in Yellowstone Lake were historically monitored each September by standardized lake-wide gillnetting using a range of mesh sizes set only in shallow water at 11 sites located around the lake. The contemporary (described above) and historical data series were combined (1980 – 2022) using a General Additive Model (Figure 7). During the late-1990s and 2000s, when the lake trout population was expanding, cutthroat trout abundance was low. During 2012 – 2022, a period of intensive lake trout suppression and population decline, cutthroat trout abundance substantially recovered to near pre-lake trout levels, surpassing secondary and primary conservation benchmarks (desired conditions) for the assessment gillnetting described in the 2010 Native Fish Conservation Plan.

Cutthroat Trout Spawning Tributary Surveys

Resource Management and Bear Management Office staff have conducted visual surveys of tributaries near Lake and Grant each spring since 1989 for spawning cutthroat trout and evidence of predation by bears. In the 1990s, prior to the

Eight large live entrapment nets were placed at eight shallow water sites to capture cutthroat trout and lake trout in 2022. Over an eight week period the traps were regularly lifted to tag fish and remove large lake trout.

lake trout-induced decline, thousands of spawning cutthroat trout were observed in these streams and bear use of cutthroat trout as a food resource was high. Surveys in 2022 (late-May to Late-June) on nine tributaries counted a total of 280 spawners of which a majority were found in Bridge Creek (57%) and Little Thumb Creek (32%). Although few spawning cutthroat trout were found, cameras placed by Bear Management Office staff captured video and confirmed that bears were feeding on them. Because cutthroat trout use of small front-country streams remains low, we speculate that the increased abundance of juveniles within the lake over the past decade originated from spawners in the larger (unmonitored) rivers, such as the Yellowstone River and tributaries upstream and downstream of the lake. We are currently collaborating with researchers at Montana State University and University of Wyoming to document the origins of juvenile cutthroat trout recruiting to Yellowstone Lake.

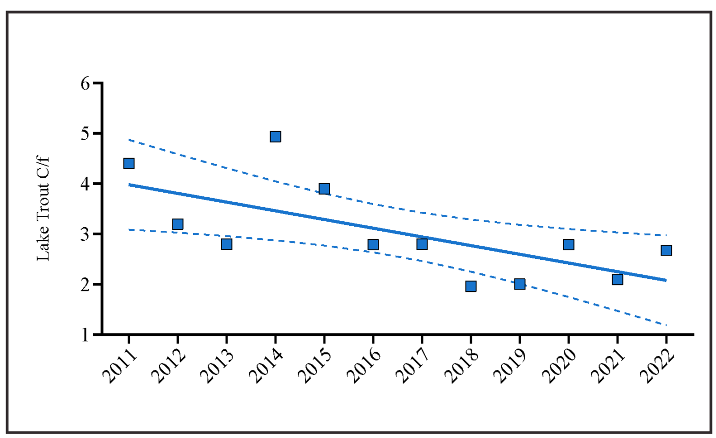


Figure 5. Catch-per-unit-effort (C/f) of lake trout caught in 100 meters of gillnet per night during the annual standardized gillnet assessment surveys in Yellowstone Lake, 2011–2022. The blue line represents a simple linear regression model with 95% confidence intervals (dashed lines).

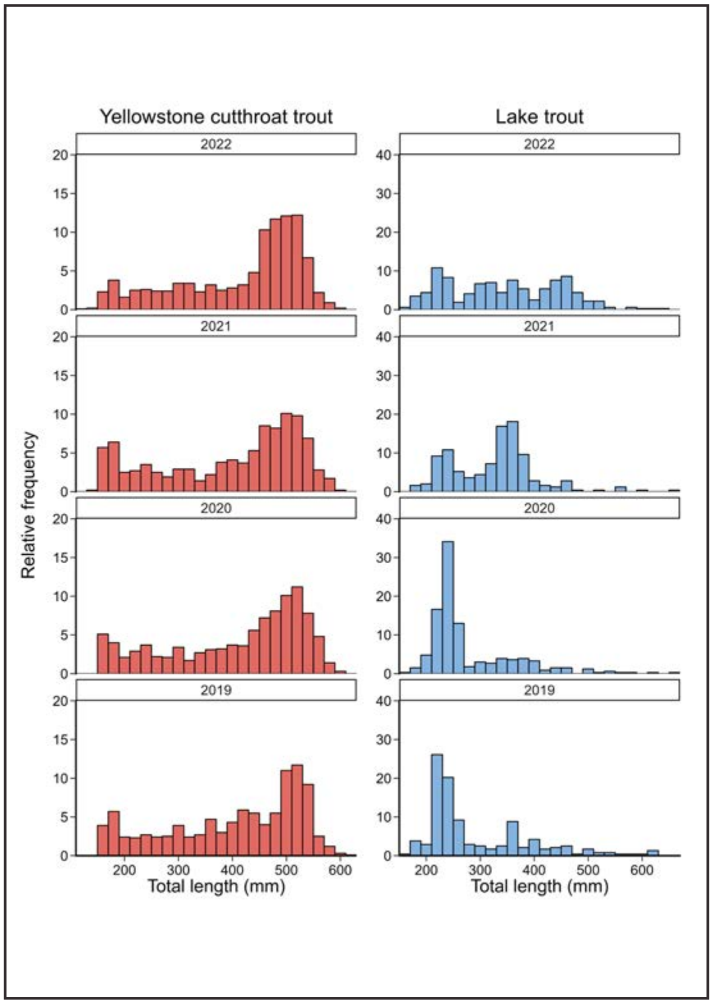


Figure 6. Length frequency plots of cutthroat trout (red; left panel) and lake trout (blue; right panel) caught in the annual standardized gillnet assessment 2019 - 2022.

Whirling Disease in Cutthroat Trout

Following the 1998 discovery of the exotic parasite *Myxobolus cerebralis* (cause of whirling disease) in cutthroat trout in Yellowstone Lake, extensive research was conducted to determine the prevalence and severity of the disease throughout the lake and several of its spawning tributaries. Extensive surveys for *M. cerebralis* are conducted every five years to assess for changes that could potentially affect cutthroat trout recovery. In juvenile and adult cutthroat trout within Yellowstone Lake, prevalence of infection has ranged from 19.6% in 1999-2001, 10% in 2012, and 16.5% in 2017. During lake-wide assessment netting in 2021, we collected samples (heads) from 256 of the cutthroat trout mortalities to assess in the lab using qPCR (genetic methods) as has been done previously. A total of 39 (15%) of the samples tested positive, suggesting prevalence within the lake over the past two decades has remained stable.

In spawning tributaries, we have previously placed "sentinel" cages in up to 24 tributaries around the lake during mid-summer to expose cutthroat trout fry for potential infection by *M. cerebralis*. Pelican Creek was the only stream with consistently high infection levels. During 2022, rather than exposing fry, we instead collected water samples from 57 (nearly all) cutthroat trout spawning tributaries to assess for the presence of *M. cerebralis* environmental DNA (eDNA). Three samples were collected from most tributaries, resulting in 184 total samples that were tested using qPCR. Of these, only two samples, both from Pelican Creek, were positive for *M. cerebralis*, suggesting that overall prevalence within

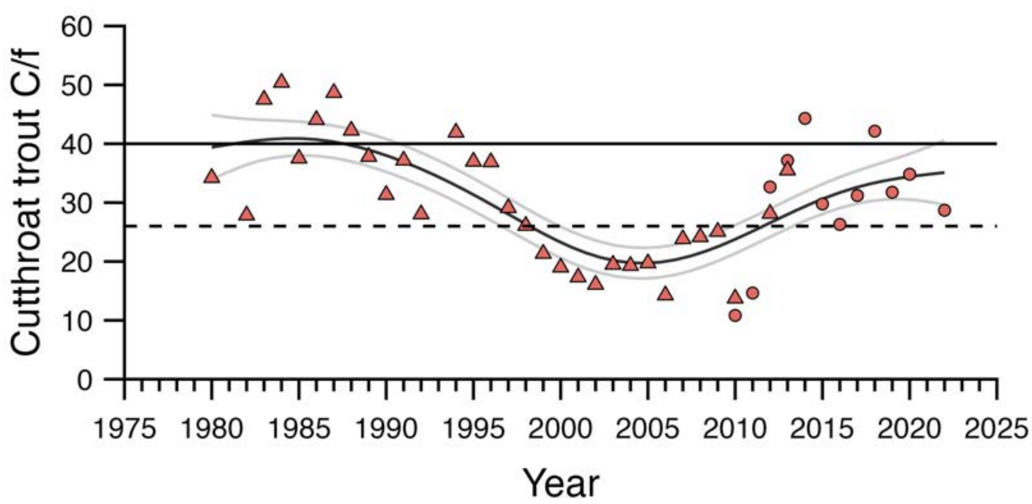


Figure 7. Recovery of Yellowstone cutthroat trout estimated by annual standardized gill-netting assessments on Yellowstone Lake, 1980 – 2022. Horizontal lines represent the primary (solid line) and secondary (dashed) conservation targets (desired conditions) for cutthroat trout following the suppression of invasive lake trout. Data points represent the average catch-per-unit-effort (C/f) of cutthroat trout each year. Triangles represent historical methods, and circles represent contemporary methods. The curved line is a General Additive Model fit to the data points and shading around it represents the error (80% confidence interval) associated with the model. Special thanks to Dr. Christopher Guy, U.S. Geological Survey, Montana Cooperative Fishery Research Unit, for creating this figure.

The average lake trout CPUE (all three depth strata) during assessment gillnetting in 2022 was 2.67 (1.95 – 3.40; 95% CI) fish/100-m net nights, which was a 25% decrease from the 2020 CPUE (Figure 5). Between 2011 and 2022, the CPUE ranged from 1.96 (1.44 – 2.48; 95% CI) to 4.86 (3.39 – 6.33). This is an additional promising indication that the suppression gillnetting is reducing the density of this invasive population. Lake trout size structure shifted from being dominated by fish around 250 mm long in 2019 and 2020 to most of the fish ranging in length from 300-400 mm in 2021 and 2022 (Figure 6).

the Yellowstone Lake basin continues to remain relatively low and stable. Whirling disease being restricted to just one spawning tributary should reduce the effect of this exotic disease on recovery of the cutthroat trout population lake-wide.

Native Fish Conservation in Streams & Small Lakes

Westslope Cutthroat Trout and Arctic Grayling

Several projects have been implemented to expand the ranges of native westslope cutthroat trout and Arctic grayling to contend with a changing climate, warming waters, and nonnative species in the Yellowstone ecosystem (Figure 1; Table 1). A project recently completed in the upper Gibbon River drainage includes Grebe, Wolf, and Ice lakes, and the Gibbon River upstream of Virginia Cascades. Removals of nonnative fish occurred autumn 2017 through 2020, and westslope cutthroat trout and Arctic grayling stockings began immediately in 2017 (Table 1). Angling has been successful for both species post-stocking, and natural reproduction of westslope cutthroat trout was documented in spawning tributaries to Grebe and Wolf lakes in 2022. Downstream dispersal of both species indicates the upper Gibbon River may serve as a fish source for the lower Gibbon River. Native fish recovery will continue to be monitored in the following years.

East Fork Specimen Creek (Figure 1) had westslope cutthroat trout stocked during 2007 – 2012 following rotenone treatments to remove nonnative brown trout and hybridized cutthroat/rainbow trout (Table 1). Although post-project surveys through 2016 detected only genetically pure westslope cutthroat trout in the restoration area, surveys in 2019 indicated that hybrid trout had reinvaded lower East Fork Specimen Creek—probably by breaching the log barrier that was constructed in 2008. To curtail the invasion, 3.7-miles of lower East Fork Specimen Creek was retreated in 2021 to remove hybridized fish and preserve genetically pure westslope cutthroat trout farther upstream. The log barrier was inspected in autumn 2022 to assess potential impacts from the 500-year Yellowstone flood, which appeared to be minimal given its 10-year life expectancy. A new permanent barrier is needed on the Specimen Creek mainstem to protect genetically-pure westslope cutthroat trout in upper East Fork Specimen Creek and High Lake, and to restore westslope cutthroat trout to North Fork Specimen Creek in the future.

We have stocked native westslope cutthroat trout or Arctic grayling, or both, to 64.2 stream miles and 281 lake acres in the Gallatin and Madison watersheds in the past two decades (Figure 1; Table 1). The headwater restoration areas were created by constructing artificial (log or concrete) barriers,

Table 1. Completed restoration projects for westslope cutthroat trout (WCT), Arctic grayling (AGR), and Yellowstone cutthroat trout (YCT), with restoration area size, years areas were treated with rotenone to remove nonnative or hybridized trout and restocked with native species, and numbers of eyed embryos and fish stocked into restoration areas through 2022.

	Size[1]						
Restoration area	Stream (km)	Lake (ha)	Treatment years	Species	Stocking years	Embryos stocked	Fish stocked
East Fork Specimen Creek[2]	13	2.8	2006, 2008-2009, 2021	WCT	2007-2012	WCT: 15,398	WCT: 2,964
Goose and Gooseneck lakes	4.8	17	2011	WCT	2013-2014, 2018	--	WCT: 15,000 AGR: 18,049
Elk, Lost, and Yancy creeks	9.6	--	2012-2014	YCT	2015-2016, 2018	YCT: 2,000	YCT: 1,170
Grayling Creek	56.3	--	2013-2014	WCT, AGR	2015-2017	WCT: 58,873 AGR: 150,000	WCT: 943 AGR: 60,000
Gibbon River (upper)[3]	34.1	93.9	2017-2020	WCT, AGR	2017-2021	WCT: 24,190	WCT: 78,000 AGR: 170,200
Soda Butte Creek[4]	24	--	2015-2016	YCT	--	--	--
Total:	141.8	113.7				YCT: 2,000	YCT: 1,170
YCT:	33.6	--				WCT: 98,461	WCT: 96,907
WCT/AGR:	108.2	113.7				AGR: 150,000	AGR: 248,249

[1]Stream length in kilometers (km) and lake area in hectares (ha)

[2]Includes High Lake

[3]Includes Grebe, Wolf, and Ice lakes

[4]YCT captured and held prior to treatment and released following nonnative brook trout removals

Fisheries Biologist Andriana Puchany with a westslope cutthroat trout from Wolf Lake in the upper Gibbon River watershed.

modifying bedrock waterfalls, or using existing falls that were naturally impassible by invasive fish located downstream. Nearly 200,000 westslope cutthroat trout and nearly 400,000 Arctic grayling were stocked across four large restoration areas in the park (Table 1).

Yellowstone Cutthroat Trout

Efforts to preserve Yellowstone cutthroat trout outside of Yellowstone Lake are primarily focused on the northeastern region of the park. The Yellowstone River downstream of the Lower Falls at Canyon, the Lamar River, and several tributaries (Figure 1), support large-river cutthroat trout that make long-distance spawning migrations each year. The system also supports an abundance of genetically pure, stream-resident cutthroat trout in headwater tributaries. Unfortunately, introduced nonnative rainbow and brook trout continue to invade and pose a major threat to the continued existence of genetically unaltered Yellowstone cutthroat trout and the ecosystem they help support.

Nonnative trout in the northeast region of the park are being aggressively suppressed through a must-kill angling regulation, selective removals by electrofishing, construction of barriers, and rotenone treatments. Projects have mainly focused on the Lamar River and Slough Creek where suppression of rainbow and hybridized trout occurs annually. Access to the Lamar River watershed during 2022 was restricted to its lower reaches due to roads washed out by the Yellowstone flood. Yellowstone cutthroat and rainbow/hybrid trout accounted for 62% and 38% of our catches by raft electrofishing on the lower Lamar River and 27% and 73% in lower Slough Creek. Buffalo Creek, a large tributary of Slough Creek, continues to be the ultimate source of rainbow trout invading the Lamar River watershed. Future actions by the park and cooperating agency partners aim to mitigate for this rainbow trout threat. The NPS is also collaborating with researchers at Montana State University to implement a long-term monitoring plan to document improvement in the Yellowstone cutthroat trout population due to the numerous actions to conserve them.

Soda Butte Creek, a large tributary of the Lamar River, was treated with rotenone in 2015 and 2016 to remove non-native brook trout upstream of Ice Box Canyon. In both years, extensive electrofishing was done to collect Yellowstone cutthroat trout and hold them in an untreated reach while rotenone applications occurred. The Yellowstone cutthroat trout were returned to Soda Butte Creek following the treatments. The project was jointly conducted by the NPS, U.S. Forest Service, Montana Fish, Wildlife & Parks, and Wyoming Game & Fish Department. Electrofishing surveys and environmental DNA (eDNA) testing were conducted in subsequent years, confirming that all brook trout were removed. Electrofishing documented the strong recovery of Yellowstone cutthroat trout in Soda Butte Creek in the years following the rotenone treatment (Figure 8). For five years (2017-2021) no brook trout were found by electrofishing or detected by eDNA during annual routine monitoring. In autumn 2022, however, several were unfortunately captured within the park upstream of Ice Box Canyon. It is unknown where these brook trout came from. The closest known brook trout populations to upper Soda Butte Creek are in public and private waterbodies north of the park boundary. The brook trout may have been washed out of these waters and entered Soda Butte Creek during the historic floods of 2022. They also may have been illegally introduced or are decedents of fish that (unknowingly) survived the 2015-16 treatments. Plans are underway to eliminate this renewed brook trout threat to the Lamar River watershed.

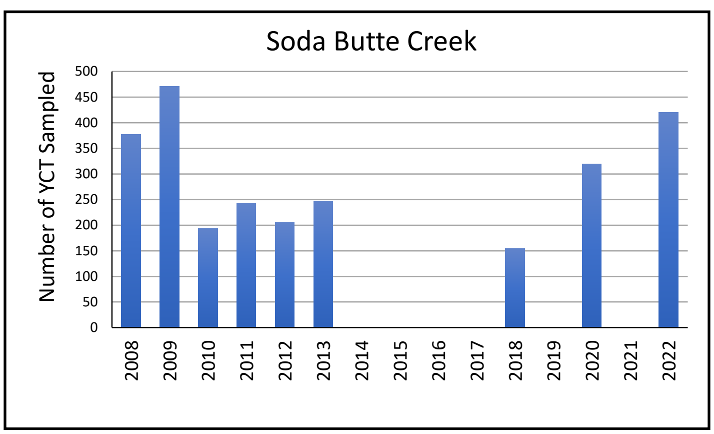
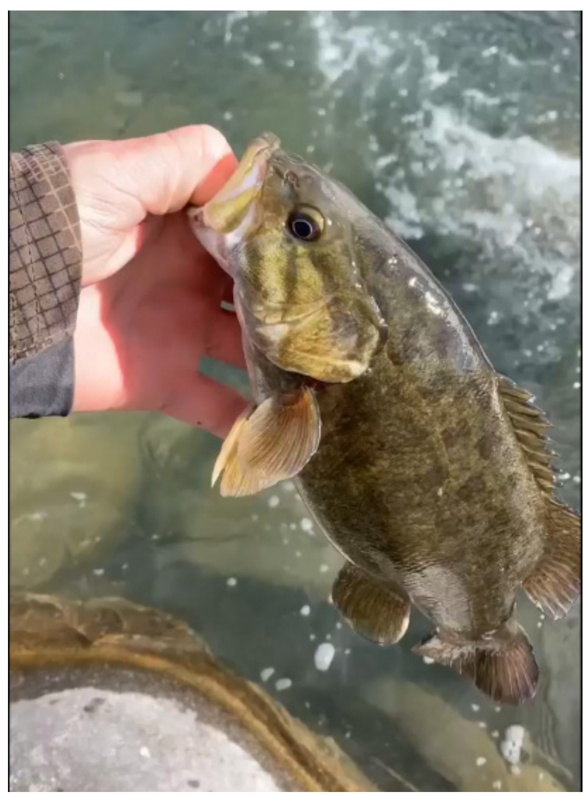


Figure 8. Total number of Yellowstone cutthroat trout (YCT) caught by electrofishing a standardized reach in upper Soda Butte Creek, 2008-2022. No sampling occurred 2014 – 2017. The creek was treated with rotenone to remove all nonnative brook trout in 2015 and 2016, and by 2022 YCT abundance recovered to pre-treatment levels.

Invasive Smallmouth Bass in the Yellowstone River

On February 19, 2022, an angler caught a smallmouth bass from the Gardner River at its confluence with the Yellowstone River immediately north of the Yellowstone National Park boundary. The smallmouth bass (scientific name *Micropterus dolomieu*) is native to the eastern and central United States and southern Canada but have been in the lower Yellowstone River downstream of Billings for over 30 years. Recently, however, anglers and biologists have reported higher numbers upstream of Billings, near Laurel and Big Timber Montana. Previously, the most upstream extent of smallmouth bass was in Paradise Valley near Emigrant where a single fish was caught by Montana biologists.

Smallmouth bass are an evolutionarily-advanced, prolific, and highly predatory fish species. In locations elsewhere in North America where they have been introduced, they have caused severe declines in native trout and salmon populations. Warming river temperatures may have facilitated the upstream movement of smallmouth bass in recent years, contributing to the species being present at the north Yellowstone National Park boundary. Climate-induced changes to river flows and temperatures may exacerbate the upstream movement and persistence of smallmouth bass. Yellowstone National Park implemented a must-kill requirement for all smallmouth bass caught by anglers in the future.



Smallmouth bass caught by an angler from the Gardner River at its confluence with the Yellowstone River. (Photo - Raef Smalley.)

PROJECTS BY GRADUATE STUDENTS

During 2022, the following graduate students assisted the Native Fish Conservation Program with research efforts.

Michelle Briggs (Doctor of Philosophy candidate) Committee chair: Dr. Christopher Guy, USGS Cooperative Fisheries Research Unit, Department of Ecology, Montana State University. Title: Current status of Yellowstone cutthroat trout in Yellowstone Lake and responses to ongoing lake trout invasion. Status: Field work and analyses ongoing.

Hayley Glassic (Doctor of Philosophy) Committee chair: Dr. Christopher Guy, USGS Cooperative Fisheries Research Unit, Department of Ecology, Montana State University. Title: A whole-ecosystem assessment of the Yellowstone Lake food web throughout lake trout suppression and Yellowstone cutthroat trout recovery. Status: Graduated 2022.

Drew MacDonald (Master of Science candidate) Committee Chair: Dr. Christopher Guy, USGS Cooperative Fisheries Research Unit, Department of Ecology, Montana State University. Title: Evaluating age 0-2 lake trout densities at confirmed spawning sites in Yellowstone Lake. Status: Field work and analyses ongoing.

Isabella Sadler (Doctor of Philosophy candidate) Committee chair: Dr. Lusha Tronstad, Invertebrate Zoologist, Wyoming Natural Diversity Database, University of Wyoming. Title: Nutrient dynamics related to suppression of invasive lake trout in Yellowstone Lake. Status: Project development underway.

Cody Vender (Master of Science candidate) Committee Chair: Dr. Christopher Guy, USGS Cooperative Fisheries Research Unit, Department of Ecology, Montana State University. Title: Evaluating cutthroat trout individual growth before and after the lake trout invasion of Yellowstone Lake. Status: Project development underway.

Keith Wellstone (Master of Science candidate) Committee Chair: Dr. Alexander Zale, USGS Cooperative Fisheries Research Unit Leader, Department of Ecology, Montana State University. Title: Assessment of sampling methods for monitoring fish populations in the Lamar River watershed. Status: Field work and analyses ongoing.

PUBLICATIONS IN SCIENTIFIC JOURNALS 2022

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Yellowstone fish crew in 2022 included (L to R) Ken Doyle, Pat Bigelow, Brian Ertel, Andy Puchany, Bonnie Dana, Haley Taylor, Kara Clarke, Michelle Briggs, Garrison Ferone, Valerie Kuppek, Matt Shaughnessy, Ciera Pitts, Karly Algerholm, Carter Beaves Lewis, Carter Bloxsom, Sadie Ainsworth, Cody Vender, Jax Vernacchia, Drew MacDonald, Phil Doepke, David Swisher, and Todd Koel.

Back cover photo: Yellowstone cutthroat trout in the South Arm of Yellowstone Lake. Rear cover photo credit: Christopher Guy, USGS Montana Cooperative Fishery Research Unit

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*All photos are NPS unless noted.