Restoration of Fluvial Populations of Native Trout

Westslope Cutthroat Trout Status

For much of the past ten years, we have increased our efforts to preserve all remaining populations of westslope cutthroat trout, one of the rarer native aquatic species in the park. Similar to other salmonids in the western U.S., many populations of westslope cutthroat trout have been substantially reduced as a result of interbreeding with other trout, particularly Yellowstone cutthroat trout and non-native rainbow trout. Genetic analyses from early surveys suggested that few, if any, pure populations remain in the Gallatin and Madison river basins, which comprise the historical range of westslope cutthroat trout in the park. Such laboratory analyses are often preferred over field classifications, because they provide a more accurate determination of an individual trout's genetic makeup when compared to classifications based on phenotypic characteristics such as spotting patterns and presence or absence of basibranchial teeth.

Additional genetic analyses in the late 1990s indicated that the park's only pure population of westslope cutthroat trout resided in North Fork Fan Creek, a tributary of the Gallatin River. Consequently, sampling and monitoring of population abundance and life history patterns were focused on that stream.[27] However, analysis of more recent genetic samples taken from this population has suggested that this suspected pure population has become hybridized with rainbow trout. We have now collected another completely new set of genetics samples from the North Fork Fan Creek population, in order to resolve this issue.

When analyses of the additional tissue samples (175 total) recently collected from the Fan Creek drainage are completed, resolution of the equivocal genetic status of the westslope cutthroat trout population there should be achieved. In the interim, the Aquatics Section has concentrated on expanding genetic inventories in the historical westslope cutthroat range in the park. Although we suspect that the Specimen Creek population remains a hybrid swarm, with Yellowstone cutthroat trout and rainbow trout genes commonly found in most of the westslope cutthroat trout there, we collected samples from the majority of fish this year for genetic analyses. Because these samples were collected from a variety of locations, it is hoped that the new genetic analyses will verify whether the amount of hybridization has increased in this watershed since the survey was last done in 1994, and if there are fish within the population that are only minimally hybridized.

Specimen Creek as the Initial Restoration Site

Faced with uncertainty about the continued existence of any genetically pure westslope cutthroat trout populations, the Aquatics Section began surveying other streams in the historical westslope cutthroat trout range within the park in 2004, concentrating on Specimen Creek. This watershed lies immediately north of Fan Creek, and is similar in size. A previous survey in 1994 indicated that the Specimen Creek trout population is highly hybridized with rainbow trout. Before this stream could be considered or rejected as a potential site for westslope cutthroat trout

NPS/DAN MAHONY

East Fork Specimen Creek is currently home to hybridized cutthroat trout and is a good location for future westslope cutthroat trout restoration within Yellowstone National Park.

restoration, updated, detailed information about the existing population needed to be collected. In 2004, three 100-m sections in East Fork Specimen Creek, two sections from North Fork Specimen Creek, and one mainstem site downstream from the confluence of the forks were sampled with backpack electroshockers. Westslope cutthroat trout or their hybrid forms were captured at all six sites, but mottled sculpins (*Cottus bairdi*) were only collected upstream as far as the low gradient (downstream) areas of each fork. This suggests that distribution of mottled sculpins may be limited by their inability to migrate through steep, higher velocity, upstream reaches of the watershed.

Estimated abundance of trout was low in all sections of the North Fork Specimen Creek, and only two were captured during the three-pass removal effort at the upper site. Characteristic of other headwater stream populations in the area, most of the cutthroat trout we sampled from Specimen Creek were not very long (<200 mm); the largest fish were captured in the middle section of the East Fork (Figure 9). The low abundance and small size of the cutthroat trout in Specimen Creek suggests that productivity in this stream is relatively low. Conductivity (an indirect measure of productivity) never exceeded 50 micromhos/cm, and water temperature was rarely higher than 10ºC. The largest fish we sampled were two rainbow trout and a brown trout at the mainstem site. This section was also fished on numerous occasions in 2004, in conjunction with the Volunteer Flyfishing Program. This group of directed anglers fished for a total of about 850 hours, and caught 28 cutthroat trout and 12 rainbow trout. Lengths of the angler-caught trout in the mainstem section were similar to those from the electrofishing survey.

Unlike many other areas within its historical range, habitat degradation and excessive harvest rates by anglers do not appear to be the primary reason for the decline of westslope cutthroat trout in Yellowstone National Park. Rather, the extensive stocking and subsequent establishment of populations of non-native competing species (brown trout [*Salmo trutta*], and interbreeding rainbow trout and Yellowstone cutthroat trout) during the first half of the twentieth century has led to a serious reduction in the park's resident westslope cutthroat trout. Our electrofishing, genetic, and radio-telemetry surveys during the past five years have revealed that a genetically pure population of westslope cutthroat trout may no longer be present in the park. Complete protection of any remaining westslope cutthroat trout populations will require that they be permanently protected from sympatric non-native species. The preferred method for perpetuating a native population consists of barrier construction (or use of an existing, natural barrier) to prevent upstream migration of competing species into westslope cutthroat trout habitats.[28] Removal of all fish from the restoration area is needed before

A genetically pure population of westslope cutthroat trout may no longer be present in the park.

genetically pure fish can be reintroduced.

There are several sites in the Specimen Creek watershed that are highly suitable for barrier construction. The typical site is in a high gradient area of narrowly confined stream channel. Large cobble and boulder substrate and dense wooded riparian areas would provide natural construction materials. In the East Fork, in particular, potential barrier sites are far enough apart to facilitate a sequential downstream restoration project. The cold temperatures and small size of the fish captured in Specimen Creek suggest that only a limited number of cutthroat trout could be expected to persist in this stream when they are reintroduced. However, the fact that this watershed contains some of the most hybridized cutthroat trout found in the park is good reason for restoration to begin there.

An additional consideration for restoration of the Specimen Creek watershed relates to the presence of Yellowstone cutthroat trout in a headwater lake. In 1937, 16,000 Yellowstone cutthroat trout were stocked into High Lake, whose outlet forms the beginning of East Fork Specimen Creek. This lake supports a small local fishery, which, in a typical year, has an estimated 35–50 anglers. Catch rates for Yellowstone cutthroat trout are consistently higher than one fish per hour. An on-site examination of the lake's outlet verified that there are no barriers preventing High Lake fish from migrating downstream. Because of this, complete protection of the westslope cutthroat trout in Specimen Creek will require chemical treatment of High Lake prior to any serious reintroduction efforts. An antimycin treatment of this lake was actually recommended for a restoration project by the park in 1970, but was not undertaken. None of the headwater lakes in the North Fork Specimen Creek basin contain fish, so lake treatments would not be required there. Much of that drainage is low gradient, and the greatest ongoing hybridization threat is continued interaction with non-native species from the mainstem of Specimen Creek and the Gallatin River.

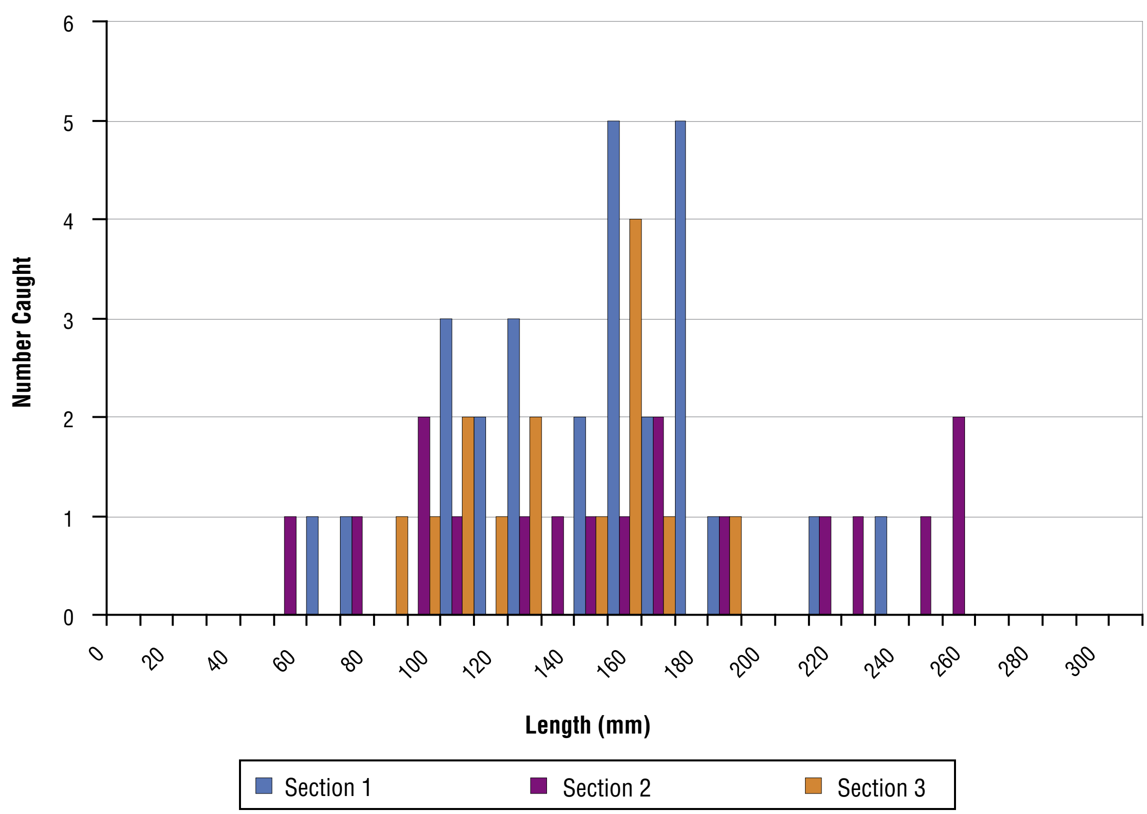

Figure 9. Length-frequency distribution of westslope cutthroat trout (hybrids) captured during electrofishing surveys at the East Fork of Specimen Creek, 2004.

Westslope Cutthroat Trout Restoration Goals

Our overall goal for westslope cutthroat trout restoration within Yellowstone National Park is to reverse the further loss of genetic integrity and establish new, genetically pure populations. Because of its close proximity to North Fork Fan Creek, and the fact that its trout population is highly hybridized, Specimen Creek, especially the East Fork, will be our focus for westslope cutthroat trout restoration in the short term. To do this, the objectives for our work planned for 2005–2006 include:

1. Examine potential for the establishment of a temporary refugia (including laboratory isolation) of westslope cutthroat trout from North Fork Fan Creek (which may still be genetically pure).

2. Complete field surveys for trout, macroinvertebrates, amphibians, and stream morphology in East Fork Specimen Creek.

3. Complete planning documents to examine alternatives for the required restoration (removal of non-native fish species and restocking with genetically pure westslope cutthroat trout) within East Fork Specimen Creek.

Our long-term goals include the construction of a series of temporary log barriers, followed by removal of non-native and hybridized trout in a stepwise manner from upstream to downstream along the East Fork Specimen Creek. Removal will initially be accomplished by using angling (fish rescue and movement downstream and out of the restoration area), followed by complete depopulation using antimycin. The depopulated reach will then be restocked with genetically pure westslope cutthroat trout from an upper Missouri River strain brood source and/or from the nearest neighbor, which is North Fork Fan Creek.

PHOTOS BY NPS/BILL VOIGT

Hybridization with non-native rainbow trout is a significant threat to the persistence of cutthroat trout within Yellowstone National Park.

Specimen Creek will be our focus for westslope cutthroat trout restoration in the short term.

Yellowstone Cutthroat Trout Restoration Goals

Recently, a multi-agency, rangewide status assessment was completed for Yellowstone cutthroat trout, which included all the waters within the range of this subspecies in Yellowstone National Park.[29] In addition, the Aquatics Section has been systematically completing surveys of stream systems within the historical range of this subspecies within the park. Results of this work have revealed that genetically pure fish exist only in a fraction of their historical range in rivers and streams outside the Yellowstone Lake basin (Figure 10). Invasion of stream systems by non-native species is continuing in the park, and remaining genetically pure Yellowstone cutthroat trout populations are being lost, with the most recent example being the loss of the world-class genetically pure fishery of Slough Creek.[30] Although

Genetically pure fish exist only in a fraction of their historical range in rivers and streams outside the Yellowstone Lake basin.

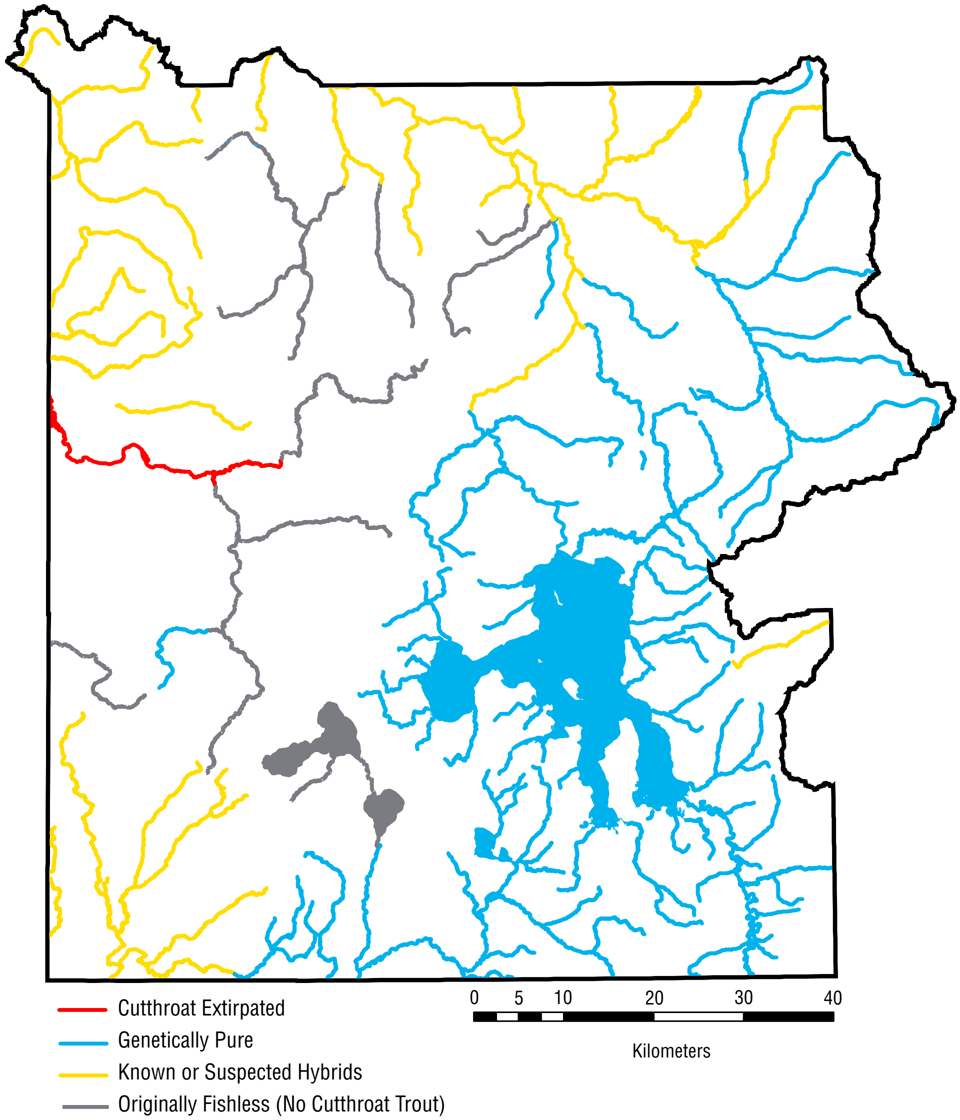

Figure 10. Genetic integrity of cutthroat trout within Yellowstone National Park. Streams tributary to Yellowstone Lake represent the lake's adfluvial cutthroat trout; most do not support stream resident populations.

broodstocks for Yellowstone cutthroat trout are being developed by partner agencies, these stocks have been very difficult (at best) to produce, and their stability should not be assumed.[31] Because of this, the Aquatics Section continues to take steps to ensure the long-term persistence of genetically pure, wild Yellowstone cutthroat trout populations. Reversing the loss of these populations within Yellowstone National Park streams must occur now, while genetically pure fish still exist for reintroduction efforts; fluvial populations may soon be reduced to the point that they cannot effectively be used for sustaining a broodstock or for reintroduction efforts of restored streams.

Given the declining probabilities for persistence of existing populations, the overall goal for fluvial Yellowstone cutthroat trout restoration within Yellowstone National Park is to focus on watersheds within the park's northern range, and identify those that have the highest probability of success for stream restoration. Streams of the northern range were chosen for initial focus because of their accessibility; the logistics for completing stream restorations in this region are very good. Our specific objectives for 2005 to 2007 are to:

1. Review existing, historical information on fishes and habitat characteristics for all northern range watersheds.

2. Use geographic information systems to develop a tool for identifying data gaps and information needs.

3. Conduct intensive field investigations of northern range watersheds to determine the current, uppermost extent of fish distribution, species composition (native vs. non-native), and habitat characteristics, including the presence of any existing barriers to fish movement.

4. Prioritize watersheds and specifically identify those that provide the greatest likelihood of success for restoration.

5. Complete required planning documents (EA or EIS), using information compiled as described above, and complete the NEPA process that will lead to on-the-ground restoration of Yellowstone cutthroat trout within Yellowstone National Park.

After the watershed prioritization and environmental planning is completed, it is our goal to begin on-the-ground work for the restoration of watersheds. The newly created Yellowstone cutthroat trout populations will then be available for other, future restoration efforts within Yellowstone National Park and elsewhere.

Conservation of Arctic grayling requires retention of their innate ability to exist as fluvial populations.

Arctic Grayling Status within the Gibbon River

In 2004, the U.S. Fish and Wildlife Service increased the Endangered Species Act status of the fluvial Arctic grayling in the upper Missouri River drainage from a 9 to a 3.[32] Its range once

NPS/TIM BYWATER

The Gibbon River below Gibbon Falls is an area where Arctic grayling have been consistently found by anglers and electrofishing gear.

In recent years, both anglers and electrofishing surveys have consistently found Arctic grayling throughout the Gibbon River.


CHARLES WALTON

Arctic grayling have been collected by flyfishing volunteers from many reaches of the Gibbon River.


NPS/BILL VOIGT

Arctic grayling from the Gibbon River.

included much of this drainage, but now the only known remnant population is restricted to the upper Big Hole River in Montana, in an area estimated to be less than 5% of its historical range. In contrast to the still-common lacustrine/adfluvial (lake) populations of Arctic grayling in Montana and Wyoming, the fluvial form of Arctic grayling is adapted to inhabiting riverine environments year-round.[33] Conservation of Arctic grayling requires retention of their innate ability to exist as fluvial populations. In Yellowstone National Park, fluvial Arctic grayling originally existed in the Madison River, and in the Gibbon and Firehole rivers below the falls of these streams.[34] Non-native brown trout introductions and the creation of Hebgen Lake quickly led to what appeared to be the complete loss of fluvial Arctic grayling within the park by the mid-1900s.

Recent occurrences have led us to seriously re-evaluate the status of fluvial Arctic grayling within Yellowstone National Park. In recent years, both anglers and electrofishing surveys have consistently found Arctic grayling throughout the Gibbon River (Figure 11). In fact, anglers have reported catching grayling in the Gibbon River in all but one year since 1979. Our ability to interpret whether or not a viable population of fluvial Arctic grayling exists, however, is somewhat confounded by the fact that in the 1920s, adfluvial (lake-dwelling) Arctic grayling were intentionally stocked into historically fishless Grebe and Wolf lakes, located in the headwaters of the Gibbon River. Although grayling are now regularly found in the Gibbon River above and below all three of its barriers, including Gibbon Falls, it is not known if these fish are truly fluvial in their life history strategies (including successful reproduction and recruitment within the Gibbon River), or if they are merely strays moving downstream from headwater lake populations. Because of this, the Aquatics Section has initiated research with the specific goal of determining whether there is a viable population of fluvial Arctic grayling within the Gibbon River system. The work is planned for 2005–2006, and our specific objectives are to:

1. Tag grayling (using visible implant tags) and track movement of juvenile/adult fish at Grebe and Wolf lakes in the Gibbon River headwaters and in the mainstem Gibbon River above and below Gibbon Falls.

2. Conduct intensive surveys for spawning grayling during late May, June, and early July in the Gibbon River and suitable tributary streams.

3. Conduct intensive surveys for young-of-the-year (YOY) grayling using fry traps from June to October in the Gibbon River.

4. Relate spatial dynamics and any observed variation of adult/juvenile/YOY grayling to thermal, flow, and other environmental characteristics of the Gibbon River system.

This work will be completed through a collaborative effort with the U.S. Geological Survey's Montana Cooperative Fisheries Research Unit. Results will have immediate relevance for the park's management and conservation of fluvial Arctic grayling, if indeed they are found to exist here.

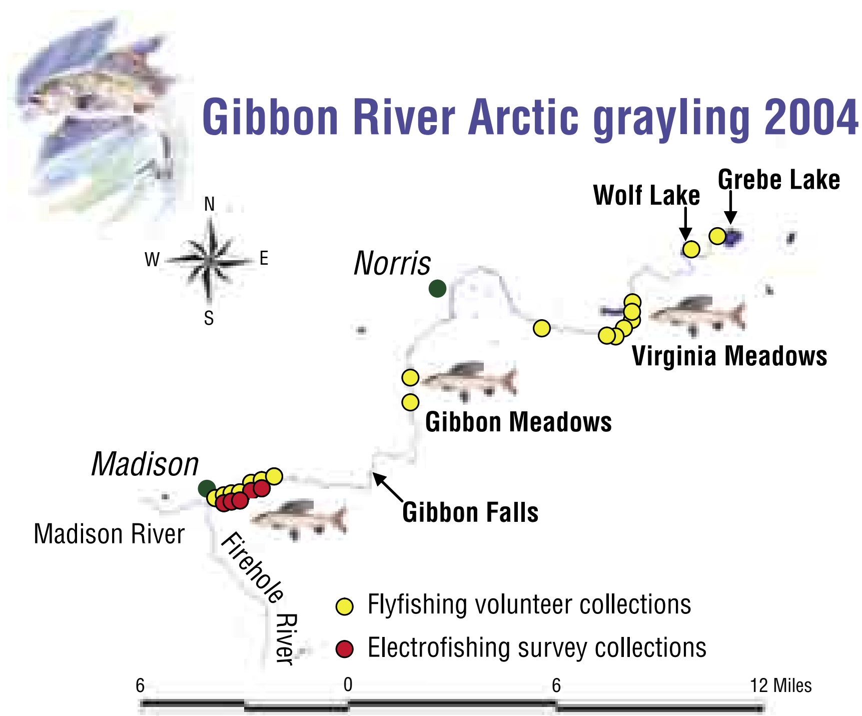

Figure 11. Sites where Gibbon River Arctic grayling were collected by flyfishing volunteers and electrofishing surveys during 2004.

Antimycin as a Native Fish Restoration Tool

Non-native fish species have been introduced into Yellowstone and many other national parks throughout the United States, resulting in the degradation (through hybridization) and displacement of native species. In such cases, ensuring the survival of native species often requires restoration. Although historically fishless waters might seem like possible restoration sites, these aquatic environments actually support unique invertebrate communities and amphibian species, and so to use them for fish restoration would mean introducing a non-native species, thereby exacerbating the very problem we would be trying to fix.

Instead, fish restoration projects are often accomplished by removing non-native and/or hybridized fish that are present in particular streams or lakes, and then restocking the waterway with genetically pure native fish. When fish removal is conducted, it is imperative that all non-native fish are removed, because if any remain, the aggressive, prolific nature of these species that out-competed the native fish in the first place will eventually allow them to return to pre-project population levels, resulting in a failure of the restoration. To be successful, the stream reach to be restored and restocked with genetically pure fish must be isolated either by an existing natural barrier (waterfall) or by the construction of an artificial log (beaver-dam style) structure. The barrier is required to prevent future invasion of the restoration area by non-native fish species existing downstream.

The only sure way to achieve complete removal of non-native fish from Yellowstone's streams or lakes is through chemical treatment by approved piscicides (fish toxins). The two chemicals that have been safely used most commonly are rotenone and antimycin. For several reasons, antimycin is generally recognized as being more effective than rotenone, especially for treatment of streams. Antimycin is a fungal antibiotic produced by certain members of the genus Streptomyces, a bacterium, found naturally in forest soils. The most widely accepted explanation as to why this bacteria produces antibiotics is that the antibiotics are an evolutionary adaptation that helps Streptomyces to reduce competition with other fungi in the soil environment.

DR. MARK BUKTENICA
CRATER LAKE NATIONAL PARK

Example of a log-style barrier used to prevent invasion of restoration areas from downstream non-native fish.

Antimycin has been applied successfully in a wide variety of both marine and freshwater fish habitats. It is absorbed into the piscine bloodstream from the water across the gills, and affects fishes at the molecular level by disrupting the process of cellular respiration. Antimycin is also effective because fish cannot sense its presence in the water and survive the treatment by avoiding and seeking refuge from the toxin, as is the case with rotenone and other piscicides. Antimycin is approved for use in many states, including Montana and Wyoming.

In streams, spring seeps, and lakes, antimycin is normally applied using drip cans, backpack sprayers, and boats, respectively. Antimycin effectively kills trout when applied at an extremely low volume per area treated, typically 5–10 parts per billion (ppb), which is 5–10 parts antimycin to every billion parts water. An antimycin concentration of 10 ppb is about 1,750 times lower than the level determined by the Montana Department of Environmental Quality to be safe for long-term human consumption, and 175,000 times lower than the safe level for short-term consumption. In addition, antimycin naturally degrades rapidly in the stream by hydrolysis, temperature, exposure to sunlight, stream turbulence, and pH. After being added to a stream, the antimycin dose loses much of its toxicity over a drop in stream elevation of about 200 feet. Because of this rapid breakdown, it is necessary to add antimycin to streams at drip stations located every 100–120 feet in vertical drop or at locations separated by the distance it takes the water in the stream to flow in one-half hour. At the downstream end of the restoration reach, typically just below the natural or artificial barrier, the antimycin is stopped/detoxified by adding potassium permanganate ($KMnO_4$) to the stream at concentrations of 1–4 parts per million. $KMnO_4$ is a strong oxidizer commonly used in drinking water supplies to oxidize metals, kill bacteria and viruses, and remove unpleasant tastes. The effectiveness of the detoxification is monitored using sentinel fish held in small cages both upstream and downstream of the $KMnO_4$ station.

Some facts about antimycin:

- Antimycin has been shown to be a safe and effective tool for the removal of non-native fish in the Intermountain West.

- Antimycin does not affect birds or mammals, including humans and livestock, and will not affect downstream drinking water.

- It is not necessary to remove animals that may exist adjacent to streams treated with antimycin, because the water is not toxic to them, and fish killed by antimycin, if consumed, will not harm them.

- Stream and lake invertebrate communities are slightly impacted by antimycin, but studies have shown that the impacts are only short-term, and the invertebrates return within a few months of the treatment.

- Because antimycin enters through gills, amphibian tadpoles are susceptible to antimycin, but conducting treatment during the fall, when tadpoles are not present, mitigates any potential impacts to amphibian populations.

- Antimycin naturally breaks down so quickly in streams that in most cases, native fish can safely be restocked to a treated stream after only 48 hours.

Antimycin was first suggested as a fish toxicant by researchers in 1963, with initial laboratory and field studies in lakes and streams completed by 1969. Since then, antimycin has been used safely and successfully throughout the United States, including in many national parks, such as Yellowstone. When Arnica Creek, a cutthroat trout spawning tributary to Yellowstone Lake, was invaded by brook trout, antimycin was used to remove them in 1985–1986. More recently, successful use of antimycin has occurred at Crater Lake, Great Basin, Great Smoky Mountains, and Rocky Mountain national parks. The experience and knowledge gained during the past three decades of use of this piscicide in our national park system and elsewhere will be used to ensure project safety and success as Yellowstone moves forward with aggressive cutthroat trout restoration projects in the coming years.

DR. MARK BUKTENICA
CRATER LAKE NATIONAL PARK

Example of an antimycin drip station used to remove non-native fish.

Adapted from the following publications:

Cerreto, K.M. 2004. Antimycin and rotenone: short term effects on invertebrates in first order, high elevation streams. Master of Science thesis. University of Wyoming, Laramie, Wyo.

Derse, P.H., and F.M. Strong. 1963. Toxicity of antimycin to fish. *Nature* 200:600–601.

Finlayson, B.J., R.A. Schnick, R.L. Cailteux, L. DeMong, W.D. Horton, W. McClay, and C.W. Thompson. 2002. Assessment of antimycin A use in fisheries and its potential for reregistration. *Fisheries* 27(6):10–18.

Finlayson, B., and 11 co-authors. 2003. Native inland trout restoration on national forests in the western United States: time for improvement? *Fisheries* 30(5):10–19.

Gresswell, R.E. 1991. Use of antimycin for removal of brook trout from a tributary of Yellowstone Lake. *North American Journal of Fisheries Management* 11:83–90.

Hubert, T.D., and L.J. Schmidt. 2001. Antimycin A use in fisheries: issues concerning EPA reregistration. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin.

Schnick, R.A. 1974. A review of the literature on the use of antimycin in fisheries. U.S. Fish and Wildlife Service, Fish Control Laboratory, La Crosse, Wisconsin.

Shepard, B.B. In press. Removal of nonnative fish stocks to conserve or restore native fish stocks. *In* P. Ferreri, L. Neilsen, and R. Gresswell, eds., Conservation of native aquatic fauna: strategies and cases (Bethesda, Md.: American Fisheries Society).

Tiffan, K.F., and E.P. Bergerson. 1996. Performance of antimycin in high-gradient streams. *North American Journal of Fisheries Management* 16:465–468.

Frontcountry Fishery Inventories

Stream Population Surveys

Stream surveys have traditionally been long-term monitoring projects that describe the responses of a fish population to a particular type of angler impact (e.g., minimum size, reduced creel, or catch and release regulations). As the number of threats to the park's fish populations has increased, however, these studies have become shorter-term (i.e., 3–5 years) as park management attempts to respond to impacts in a timely manner. In 2004, our surveys of fish populations included ongoing monitoring of road-impacted streams in many locations of the park.

The high density of brook trout indicates that Middle Creek is productive, but the small number of cutthroat is cause for concern.

Monitoring Associated with Road Reconstruction

Reconstruction of the Grand Loop Road continues to be an important management objective in Yellowstone National Park. Because a significant portion of many roads parallel stream corridors to enhance park visitors' scenic experience, road projects can potentially impact fish populations if excessive sediment is generated during construction, or improperly designed or placed road culverts impede fish passage after project completion. Several streams used by spawning and resident Yellowstone cutthroat trout are located within these construction areas. In June 2004, electrofishing surveys were conducted at several sites in the Hayden Valley portion of the road-resurfacing project between Fishing Bridge and Canyon Junction (begun in 2003). Unlike in 2003, no large cutthroat trout of spawning size were captured at these sites; only juvenile Yellowstone cutthroat trout and introduced red side shiners (*Richardsonius balteatus*) were found.

In 2003, Phase 1 (Canyon-to-Chittenden Road) of the Dunraven Pass road reconstruction was initiated. A small tributary of Cascade Creek that flows under the road here has the potential to be directly affected by construction activities. This stream is of concern because numerous cutthroat trout encompassing several age classes, including fry, were captured there in 2003 and 2004. Few of these fish are longer than 250 mm, suggesting they are juveniles. It is unknown whether larger cutthroat trout from Cascade Lake use this stream for spawning or if the trout we have captured are a stream-resident form that exhibits small size due to diminished growth rates.

Since 1999, the Aquatics Section has monitored fish populations at four locations in the Gibbon River between Gibbon Meadows and Madison Junction to assess possible road construction impacts to resident fish there. A secondary objective of our study is to document the responses of any Arctic grayling that may reside in the downstream areas to road construction activities. Most of the Gibbon River was originally barren of fish, but the sections below Gibbon Falls (Tuff Cliffs and Canyon Creek sample areas) historically contained westslope cutthroat trout and fluvial Arctic grayling. Westslope cutthroat trout have apparently been eliminated from the Gibbon River, but Arctic grayling are occasionally captured (Figure 11). The Madison-to-Norris road reconstruction project is one of the most ambitious ever undertaken in the park. After the existing road is widened to meet current federal highway standards, a new re-route and bridge over the Gibbon River will be built, and several kilometers of road will be removed. Thus, the potential for increased sediment input into the stream and associated habitat degradation is very high. More importantly, the road removal portion of the project represents one of the first attempts by the park to physically restore a section of stream channel that has been previously altered by road building.

Each year, brown trout were the most common fish collected at each sample area of the Gibbon River, and the only species captured in the Tanker Curve section. During the past several low water years, estimated brown trout abundance averaged from 400 to 800 fish per km. As in 2003, rainbow trout were only captured downstream from Gibbon Falls (but large rainbow trout longer than 450 mm were not encountered in 2004). If the rainbow trout life history in the Gibbon River involves summer migration, this observed difference in size distributions between the two years may partially be explained by different sampling periods (early September 2003 vs. late July 2004). In 2004, six different grayling were captured in the Tuff Cliffs reach. Although this represents the second-highest number of Arctic grayling captured since monitoring began, abundance of grayling in the Gibbon River remains extremely low when compared to non-native brown trout and rainbow trout.

In 1992, Yellowstone National Park released an environmental assessment detailing plans for the reconstruction of the East Entrance Road over Sylvan Pass. The first two phases were completed within the past few years, but initial work on the technically more challenging portion from Avalanche Peak to the East Entrance Station did not begin until this year. Most of the road is located along steep, avalanche-prone slopes, and the last several kilometers near the entrance station are in proximity to the Middle Fork of the Shoshone River (Middle Creek). For the fourth consecutive year, fish populations were monitored by three-pass electrofishing removal estimates at two 100-m sample sites. The lower site is entirely adjacent to the existing road, and about half of the reach length contains riprap on the outside channel bend as a form of road protection. The upper site is in proximity to the former, historic road in the valley bottom, but the channel is not constricted, and woody debris is abundant in the sample section.

Brook trout (*Salvelinus fontinalis*) were the most abundant fish caught at both Middle Creek sites in all years. Yellowstone cutthroat trout and their hybrids with rainbow trout were less abundant. Many size classes of brook trout were captured, but the cutthroat trout were typically small; young-of-the-year individuals often composed the bulk of the cutthroat trout catch. Abundance of cutthroat trout varied only slightly between the two sites and between years. In contrast, brook trout were significantly more abundant at the upper site (Figure 12). The high density of brook trout indicates that Middle Creek is productive, but the small number of cutthroat is cause for concern. Several factors may affect the reduced numbers of cutthroat trout in this stream. Brook trout are typically a superior competitor with cutthroat trout, which could explain the lack of cutthroat trout dominance in the higher-quality, upper section habitat.[35] The presence of rainbow trout suggests that the population there may be hybridized. Often, cutthroat–rainbow hybrids are not as fit as pure strain fish, and may be less able to adapt to changing environmental conditions.[36]

Road erosion also became an urgent concern this past spring, when the mainstem channel of Soda Butte Creek migrated close to the Northeast Entrance Road. At the area of concern, Soda Butte Creek is classified as a C-type channel, which is characterized by low gradient, small cobble and gravel substrate, and a meandering channel pattern. This type of channel is naturally highly erosive, and needs to be unconfined to function properly.[37] Fishery data in the immediate area of concern are limited, so Aquatics Section staff consulted with park managers and recommended that soft-material revetments would be most beneficial for the fisheries in this situation. However, due to time constraints imposed by a possible closure of the road, standard boulder riprap was used as a short-term solution to the erosion of the road base. The long-term effects of this project on the resident cutthroat trout in Soda Butte Creek are presently unknown, but ongoing monitoring will continue. Status of the cutthroat trout is further threatened by the discovery of brook trout in the headwaters of Soda Butte Creek in 2003. Montana Fish, Wildlife and Parks carried out a treatment project upstream of the park boundary in fall 2004 to eliminate the source of these potential competitors, but the treatment was not entirely successful, as a few brook trout were later captured several kilometers downstream from the rehabilitation area. Anglers have also recently reported catching brook trout in a Soda Butte Creek tributary downstream of Ice Box Canyon.

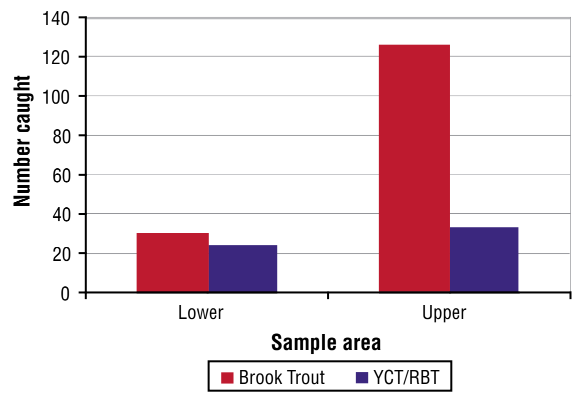

Figure 12. Number of Yellowstone cutthroat trout x rainbow trout hybrids and brook trout caught per 100 m of stream during three-pass depletion population estimates of Middle Creek in 2004.

Wilderness Fisheries of the South

Status of Cutthroat Trout in the Upper Snake River

In Yellowstone National Park, the Snake River finespotted cutthroat trout (*O. c. behnkei)* is one of the least-studied aquatic species. Although the Snake River is one of the park's larger watersheds, much of the stream has never been surveyed because of its remote location. In August 2004, in a cooperative effort with fishery biologists from the Bridger-Teton National Forest, the mainstem of the Snake River and several tributaries were surveyed for native fish species. The survey downstream from the confluence with the Heart River (approximately 30 km of river) was sampled for historical comparison with a survey conducted in 1983. An additional 20 km upstream from the Heart River–Snake River confluence was surveyed for the first time ever. Preliminary results included:

In a cooperative effort, the mainstem of the Snake River and several tributaries were surveyed for native fish species.

- Several waterfalls about halfway between the headwaters and the Heart River presumably function as barriers to upstream fish migration and separate the mainstem Snake River fish into two populations.

- Mountain whitefish (*Prosopium williamsoni*) were the most abundant salmonid downstream from Heart River.

NPS/DAN MAHONY

Yellowstone National Park fisheries technicians electrofish the Snake River.

NPS/DAN MAHONY

The finespotted form of Yellowstone cutthroat trout was found within the Snake River in 2004.

- Young cutthroat trout were found at almost all sites.

- Adult Yellowstone cutthroat trout (large-spotted) were found infrequently, and rarely exceeded 250 mm in length.

- The rare fine-spotted form (Snake River fine-spotted cutthroat trout) was only collected downstream from the confluence with the Heart River.

- Other native species collected included longnose dace (*Rhinichthys cataractae*), speckled dace (*Rhinichthys osculus*), and mottled sculpin.

- In at least two headwater tributaries, waterfalls delimited areas of historically fishless portions of streams.

The Snake River survey will be completed in 2005, with a focus on the stream's many remote, headwater tributaries. Anecdotal angler reports suggest that numerous large cutthroat trout are typically caught in the river earlier in the year, so additional sampling of the mainstem river may also be required earlier in the season to verify the accuracy of these reports. Angling effort in the Snake River comprised less than 1% of the total angling effort in Yellowstone National Park during the 2004 fishing season. Anglers reported catching predominately native cutthroat trout and mountain whitefish.

Status of Cutthroat Trout in the Upper Yellowstone River

During the park's history, there has never been a comprehensive fishery survey of the Yellowstone River upstream of Yellowstone Lake. Because of this, in 2003, the National Park Service, in cooperation with the Wyoming Game and Fish Department, initiated a fisheries assessment of this remote river. The study will help determine movements of adult Yellowstone cutthroat trout during their spawning migration in the Yellowstone River and several of its tributaries. We also hope to determine if any resident populations exist in the drainage.

Adult Yellowstone cutthroat trout were surgically implanted with radio transmitters in the Yellowstone River and several of its tributaries (Thorofare Creek, Mountain Creek, and Atlantic Creek). Sixty-five cutthroat trout were surgically implanted in 2003. An additional 67 fish were implanted with transmitters in 2004. All fish collected were measured, weighed, sexed, had scale samples taken, and were fin-clipped for genetic testing.

Trips to implant radio transmitters in 2004 began in mid-May, two weeks after ice-off from Yellowstone Lake. Fyke nets and trap nets were set in the mouth of the Yellowstone River. Two gill nets (300 feet long, 25-mm bar measure) were also used in the mouth of the river and delta as a large seine. Eight fish were captured and implanted with tags during this initial session. Our second tagging operation took place from June 21 to July 1, 2004. Sample reaches were located in the Bridger-Teton Wilderness area located just south of the Yellowstone National Park boundary. All sampling was done on the Yellowstone River from three miles south of Atlantic Creek to three miles south of Castle Creek. During this effort, 27 fish were implanted with radio transmitters. All females captured during this period were post-spawn, and males were either post-spawn or ripe, indicating that our tagging occurred after the main spawning period in 2004. Wyoming Game and Fish personnel implanted radio tags in an additional 32 fish in the Thorofare Creek watershed from July 12 to July 21, 2004. Sampling took place from the lower reaches of Open Creek and Dell Creek to the boundary of Yellowstone National Park.

Fish outfitted with radio transmitters were monitored with weekly tracking flights by fixed wing aircraft and several ground-truthing trips from June to November 2004 (Figure 13). Flights then were conducted monthly from December through mid-April 2005. Surveys to locate fish that moved into Yellowstone Lake were conducted via aircraft and boat.

Initial analysis indicates that the majority

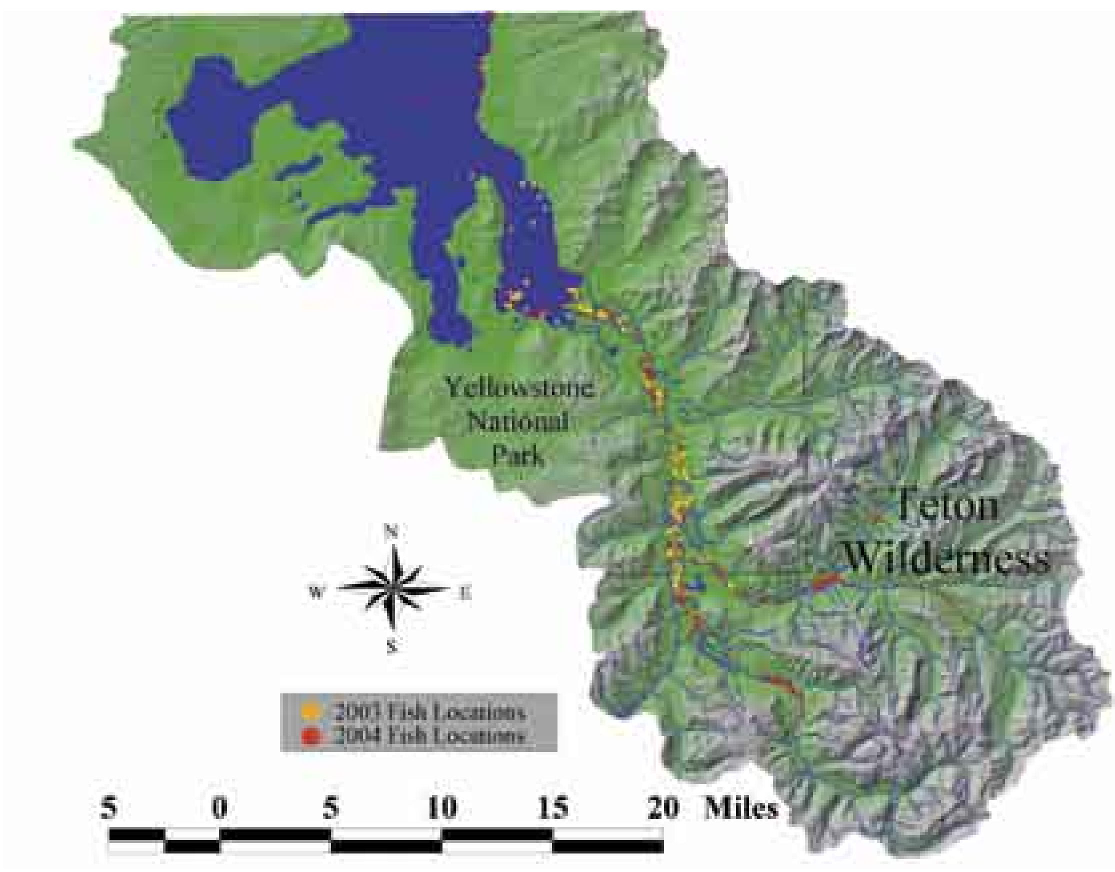

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Figure 13. Locations of Yellowstone cutthroat trout in the upper Yellowstone River system, collected and identified through aerial and ground telemetry in 2003 and 2004.

Yellowstone National Park fisheries technician Brian Ertel with a Yellowstone cutthroat trout from the upper Yellowstone River that has been outfitted with a radio-telemetry transmitter.

of adult cutthroat trout tagged in the upper Yellowstone River and its tributaries migrated back to Yellowstone Lake following the spawning period, both in 2003 and 2004. Some cutthroat trout traveled great distances to spawn. For example, several fish migrated from Yellowstone Lake upstream more than 30 miles to the upper reaches of Thorofare Creek. Several male Yellowstone cutthroat trout tagged during 2003 returned to spawn in 2004, indicating that males may spawn in successive seasons. No female fish tagged during 2003 returned during 2004, indicating that females in this system may not spawn in successive seasons.

Several known mortalities of tagged cutthroat trout were noted in 2004. One radio tag was recovered from the Molly Islands of Yellowstone Lake's Southeast Arm (most likely caused by white pelican predation), and two transmitters were retrieved from below standing dead pines in the lower river region in areas where bald eagles were frequently perched. Bald eagles may have captured the fish or may have scavenged the dead fish carcasses with radio transmitters. Monitoring of fish movement patterns is planned for at least two more field seasons, as this information is some of the first ever obtained for these remote waters of the park.

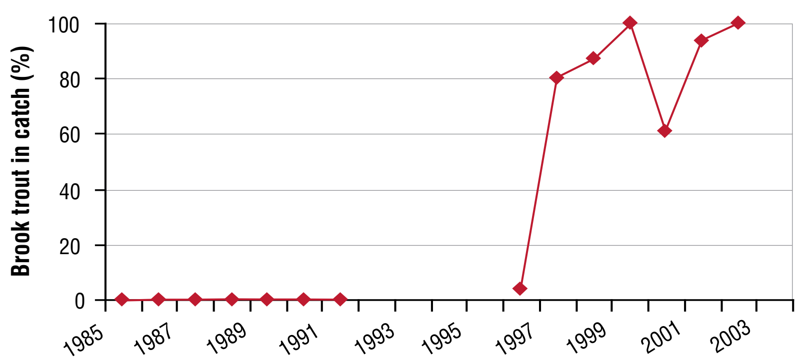

Figure 14. Brook trout reported by anglers from Pocket Lake, 1985–2002.

Pocket Lake Cutthroat Threatened by Brook Trout

From 1963 to 1986, U.S. Fish and Wildlife Service personnel surveyed 112 of Yellowstone National Park's backcountry lakes to obtain baseline data on water quality, aquatic invertebrates and macrophytes, lake bathymetry, and fish species composition and size structure.[38] This data series was meant to provide baseline data for assessing changes over time. Pocket Lake, located in a small basin 1.5 miles northwest of Shoshone Lake, was re-surveyed in 2004. Originally fishless, this lake was stocked with brook trout in 1953–1954. In 1977, the U.S. Fish and Wildlife Service chose Pocket Lake as a refugia for the depleted stock of Heart Lake Yellowstone cutthroat trout.[39] This lake was deemed an excellent refugia site for three reasons: (1) its historical fishless condition meant no native fish species would be impacted, (2) its location in a steep drainage with one small inlet and one outlet with a steep cascade would keep it isolated from other fish populations, and (3) the success of the brook trout stocked in the 1950s demonstrated it had the ability to sustain a fish population. The U.S. Fish and Wildlife Service chemically treated Pocket Lake with antimycin with the intent of eradicating all brook trout. They subsequently stocked 1,800 Yellowstone cutthroat trout from the Heart Lake drainage (900 from Heart Lake and 900 from Beaver Creek, a tributary to Heart Lake) into Pocket Lake in 1977 and 1978. When Pocket Lake was re-surveyed in 1983, four cutthroat trout and zero brook trout were collected.[40] At that time, successful recruitment of cutthroat trout had not been documented, although it was felt that it was occurring. Although Volunteer Angler Reports (VAR) have been sporadic over the years for Pocket Lake, anglers have documented catching cutthroat trout of varying sizes, supporting that at least some recruitment had occurred in the past. Unfortunately, no VAR data exist for Pocket Lake for 1992–1995. By 1996, brook trout had reappeared in the catch, and by 1997, were reportedly 80% of the catch (Figure 14). From 1997 on, cutthroat trout have been caught infrequently in Pocket Lake; only in four of the seven years since the reappearance of brook trout have anglers reported catching a cutthroat trout.

To ensure our ability to confirm the persistence of the Heart Lake cutthroat trout in Pocket Lake, we sampled the fisheries community by gillnet, angling, and snorkeling methods during August 2004. Two variable-mesh gillnets, 38.1 m long, with 7.6 m mesh panels of 19-, 25-, 32-, 38-, and 51-mm bar mesh were used. These were set overnight, perpendicular to shore—one off a steep drop, and the other in habitat more typical of the lake. Two snorkel surveys of the lake were completed, and personnel sampled by angling as time permitted. No cutthroat trout were caught in the gillnets or by angling. However, one cutthroat trout and a second fish, thought to be a cutthroat trout, were seen during the snorkel surveys. No evidence of young-of-the-year cutthroat trout was observed.

It is not known how brook trout became re-established in Pocket Lake. If the original treatment was not 100% effective, any remaining brook trout would have been able to re-populate the lake along with the introduced cutthroat trout. This is not likely, considering that almost 20 years passed before brook trout began appearing in reported catch. Brook trout do exist in Shoshone Lake, and could have gained access via the Pocket Lake outlet. This outlet passes through a narrow canyon, and although it has a steep cascade that would prevent fish passage for most of the year, it does not appear to be a complete barrier. Regardless of how brook trout became re-established, it is apparent they are now the dominant fish in Pocket Lake, where very few Heart Lake cutthroat trout persist.

The Pocket Lake brook trout population appears healthy. Age classes 1–5 were represented in the sample, and sizes ranged from 158 mm to 357 mm (Figure 15). Mean condition factor of fish sampled was 1.0, considered ideal in a trout population.

NPS/TODD KOEL

NPS/JOE FACENDOLA

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Top: *Pocket Lake was stocked with cutthroat trout from Heart Lake during 1977–1978. Surveys in 2004 indicate the cutthroat trout are now largely lost due to invasion of the lake by non-native brook trout.*

Middle: *Yellowstone National Park fisheries technician Brad Olszewski measures brook trout at Pocket Lake.*

Bottom: *Non-native brook trout (shown here) have resulted in the decline of cutthroat trout within Pocket Lake.*

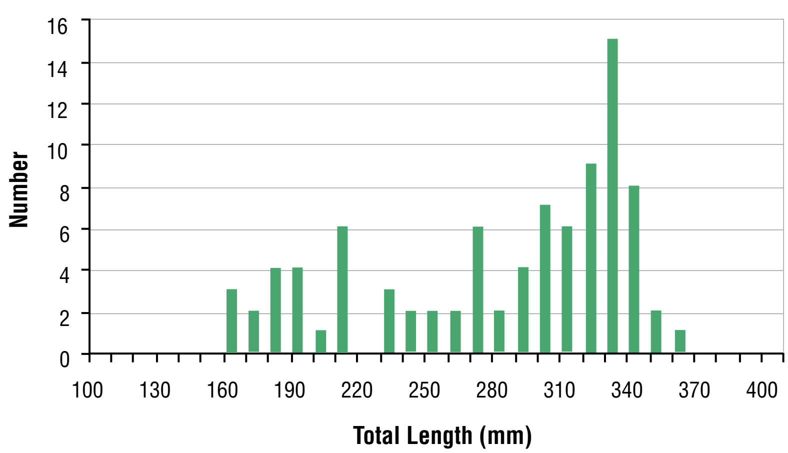

Figure 15. Length–frequency distribution of brook trout captured during gillnetting surveys of Pocket Lake, 2004.