Disease Surveys

Fish Health Surveys

The Aquatics Section continues to participate in the U.S. Fish and Wildlife Service National Wild Fish Health Survey to monitor the physical health of sampled fish populations that have not yet had a population-level health diagnosis. According to the established protocols, a subsample of fish collected by fishery personnel were lethally sampled and examined for a variety of parasitic infections and bacterial and viral diseases. Through collaboration with the Bozeman Fish Health Laboratory, approximately 27 sites within YNP have been examined by the survey (1995–2005), with many additional sites examined in the Yellowstone Lake drainage as part of the park's whirling disease research program (Figure 24). To date, two significant fish pathogens have been documented within the park: *Renibacterium salmoninarum*, the agent of bacterial kidney disease, and *Myxobolus cerebralis*, the parasite responsible for salmonid whirling disease (Koel et al. 2006).

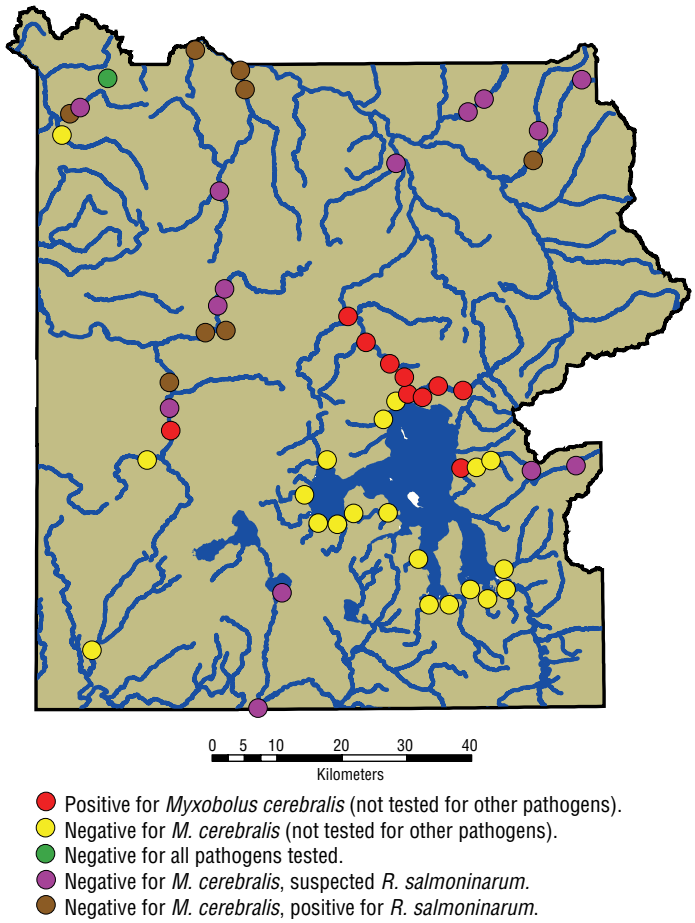


Figure 24. Stream sites examined by the U.S. Fish and Wildlife Service Wild Fish Health Survey or by sentinel cutthroat trout fry exposures, 1995–2005. Sites that tested positive for Myxobolus cerebralis (Mc)*, the cause of whirling disease, are in red.*

R. salmoninarum was confirmed by DNA polymerase chain reaction (PCR) to exist in several waters, including Canyon, Fan, and Soda Butte creeks, the Gardner, Gibbon, and Firehole rivers, and Yellowstone Lake. It is suspected that several other streams harbor *R. salmoninarum*, but its presence was not confirmed with PCR. There have been no documented fish population declines due to this pathogen in the park, and it is suspected that the pathogen may be endemic to the region. *M. cerebralis* (*Mc*) was confirmed by PCR from the Firehole River and several locations in the upper Yellowstone River drainage above the upper falls. This parasite is an introduced, exotic species native to Europe, and it has resulted in severe declines in the native cutthroat trout of Pelican Creek and, possibly, the Yellowstone River downstream of Yellowstone Lake and through the Hayden Valley reach (Koel et al. 2005).

Mc Infection of Worms and Cutthroat Trout in the Pelican Creek Watershed

M. cerebralis was first documented in YCT in Yellowstone Lake in 1998, and has since become established in two spawning tributaries within this system. Surveys conducted in 1999–2001 detected *Mc* in Pelican Creek (high infection) and in the Yellowstone River downstream of the lake outlet (moderate infection). However, sentinel fry exposures have failed to detect *Mc* in other spawning tributaries to the lake. Numbers of spawning YCT have declined significantly in the Pelican Creek tributary, but similar declines have not been observed in the Yellowstone River below the lake. Declines have been attributed to high infection risk, detected >20 kilometers upstream from the outlet in Pelican Creek in combination with increased predation pressure by non-native lake trout within Yellowstone Lake (Koel et al. 2006).

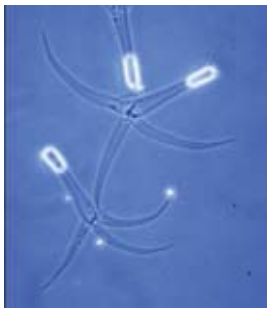
Understanding the factors that affect *Mc*

infections and YCT population declines, and the potential for the YCT population to return to historical numbers, will require knowledge of the spatial variation in *Mc* in the upper reaches of the Pelican Creek watershed. The logistics of working in these remote, backcountry areas, however, preclude using sentinel fish exposures for documentation of infection risk. In 2005, the park continued its close partnership with Montana State University's Department of Ecology, with work now aimed at the Pelican Creek backcountry. Project goals were to (1) quantify *Mc* infection risk in Pelican Creek using *Tubifex tubifex* worms (which serve as a host for *Mc*) and compare the results to those obtained by sentinel fish exposures and (2) measure variation among tubificids and habitat.

Graduate Research Assistant Julie Alexander found a uniform (100%) infection prevalence and similar high grades of infection severity in sentinel fish among six sites where fry were exposed, suggesting that whirling disease (WD) risk is high among remote, upper tributaries to Pelican Creek (Figure 25) (Alexander et al. 2006). In contrast, patchy patterns of *Mc* infection were observed in tubificids, suggesting that WD risk varies among the 25 sites she has examined for worms in the watershed. The highly variable patterns of infected tubificid abundance relative to habitat type warrants investigation. Now that infected reaches have been found in the upper Pelican Creek watershed, the next steps will be to monitor uninfected sites for colonization by the parasite, examine variation in the relative abundances of worm species, and evaluate any potential vectors of dissemination.

Potential of Avian Piscivores as Dispersal Vectors for Mc

In 2005, the park partnered with Montana State University's Department of Ecology and the USDA Animal and Plant Health Inspection Service's National Wildlife Research Center (Mississippi Field Station, Mississippi State University) to examine the role of several common fish-eating birds in the movement of *Mc* in YNP (Koel and Kerans 2004). The cutthroat trout of this system are a source of energy for many important consumer species, including several avian piscivores. Dissemination of *Mc* in the region has been attributed primarily to movement of infected fishes by humans. However, no fishes have been (legally) transported to the waters of the Yellowstone Lake basin or to many places elsewhere in Wyoming where the parasite now exists. The goal of this study is to determine the potential of American white pelicans, great blue herons, great egrets, and double-crested cormorants as dispersal vectors for *Mc*. In the Yellowstone Lake ecosystem and elsewhere, these birds feed, move among waters, and defecate. The range of these bird species includes western states with high WD severity. Daily foraging movements can be more than 150 miles. This study will closely examine the impacts of digestion on the viability of myxospores. Results will provide some of the first knowledge of avian piscivores as a potential dispersal mechanism for *Mc*, and will have far-reaching implications in assisting resource managers concerned with the protection of wild and native salmonid fisheries.



Mc *triactinomyxons (TAMs) float freely in the water column after release by* Tubifex tubifex *worms.*

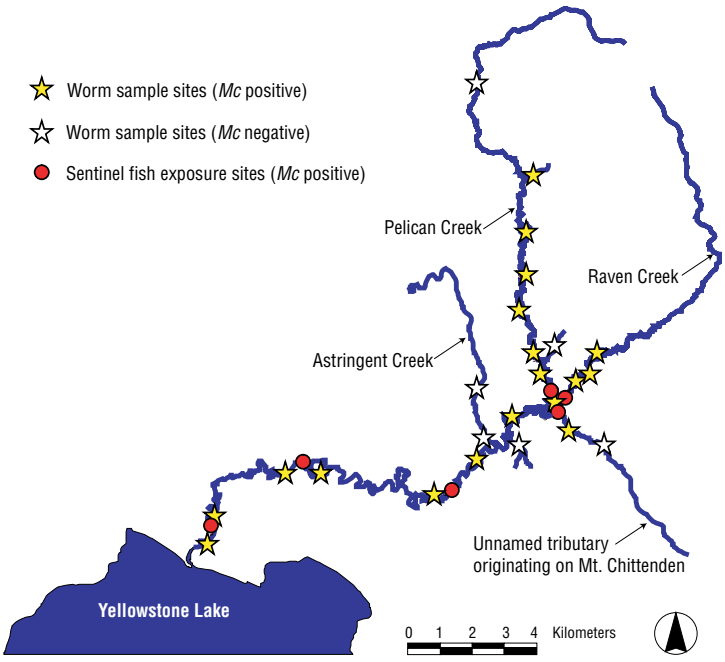


Figure 25. Pelican Creek watershed with locations that were positive for Myxobolus cerebralis (Mc) *as determined by cutthroat trout sentinel fry exposures and tubificid worm survey sites during 2004. (Image provided by Julie Alexander, Montana State University.)*

Angling in the Park

A New Framework for Regulations Proposed in 2005

Native cutthroat trout, fluvial Arctic grayling, and mountain whitefish are protected by catch-and-release-only fishing rules in the park to reduce mortality due to angling. In most waters, current park regulations allow for the harvest of only two rainbow or brown trout. However, hybridization with non-native rainbow trout and predation by non-native brook trout, brown trout, and lake trout continue to negatively affect native sportfish populations in the park.

In 2005, to reduce competition, predation, and hybridization stress on native fishes, park managers proposed to increase harvest limits of rainbow and brown trout in waters where they co-exist with cutthroat trout and Arctic grayling. The proposed regulations change is based on the presence or absence of native sportfish species, and contains a Native Trout Conservation Area and a Wild Trout Enhancement Area (YNP 2006). The proposal simplifies the regulations structure used in the past. In addition, the park sought input on the idea of requiring the use of barbless hooks as a way to reduce injury to fishes, especially in popular, heavily fished waters such as the Yellowstone River, Soda Butte Creek, and others.

Five local public meetings were held from April 4 through 18, 2005. These meetings included an update on the status of the park's fish populations and an explanation of the proposed changes in fishing regulations, followed by a question-and-answer session. In addition, a period for written public comments remained open from March 14 through August 31, 2005. A total of 506 comments were received, of which 352 (70%) were in favor of the proposed regulation changes and 18 (4%) were opposed. Three hundred seventy-six (74%) were in favor of a parkwide policy for barbless hooks, and 10 (2%) were opposed. Given the strong public support for the proposal, the park plans to implement the regulation changes in 2006.

NPS/MIKE RUHL

A barbless hook rule was proposed due to the incidence of scarred trout in several popular streams.

Trends from the Volunteer Angler Report Cards

Angling remains a popular pastime for those visiting, living near, and working in Yellowstone National Park. During 2005, a total of 51,870 people obtained special use permits for fishing the park's waters. Most anglers purchasing a special use fishing permit (required for fishing in park waters) receive a volunteer angler report (VAR) card. These cards have been distributed to anglers since 1973, and provide anglers an opportunity to share their fishing success and opinions with park fisheries managers. There was a response of almost 3,000 angler outings in 2005 through this program.

VAR cards also provide managers with an overview of angler use, fish population dynamics, and attitudes toward the fisheries resource throughout the waters of YNP. Data from 2005 indicated that anglers fished an average of 2.8 hours a day during a typical outing and fished 1.69 days during the season. Anglers who fished only one day comprised 63% of total park anglers, and 81% of them caught fish. Only 5.4% of these anglers kept fish. Anglers reported being satisfied with the overall fishing experience (75%), with the number of fish caught (62%), and with the size of fish caught (65%).

Anglers caught an estimated 522,258 fish in YNP during the 2005 fishing season. Native cutthroat trout remained the most sought-after and caught fish species, comprising 52% of the total catch, followed distantly by rainbow trout (20%), brown trout (13%), brook trout (6%), lake trout (4%), grayling (3%), and mountain whitefish (2%) (Figure 26). Overall, native species comprised 57% of the total catch.

Yellowstone Lake remained the most popular destination for anglers. An estimated 10,267 anglers fished Yellowstone Lake in 2005, representing one-quarter of all fishing effort in the park. Anglers fishing Yellowstone Lake reported catching 0.71 cutthroat trout per hour of fishing. This catch rate is less than in recent years and follows a six-year downward trend since a record high in 1998. The average length of cutthroat trout caught by anglers did not increase in 2005. At 447 mm (17.6 inches), though, it is still at an all-time high (Figure 27). The angler-reported catch rate for lake trout in Yellowstone Lake decreased in 2005 for the second consecutive year to 0.05 fish per hour. This is a positive sign that efforts to reduce lake trout are having some success. In the effort to decrease non-native lake trout, the park administration encourages anglers to fish for,

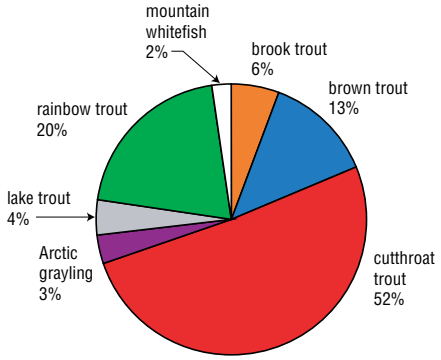


Figure 26. Total angler-reported catch by percent of fish species in Yellowstone National Park during the 2005 fishing season.

and requires them to kill all lake trout caught in Yellowstone Lake, with no size or number limitations. An estimated 5,529 lake trout were caught by anglers in Yellowstone Lake during the 2005 angling season.

Fisheries managers will continue to use VAR cards as a tool to gauge fish population trends, angler use of waters, and visitor enjoyment of the tremendous fishing opportunities that exist in Yellowstone National Park.

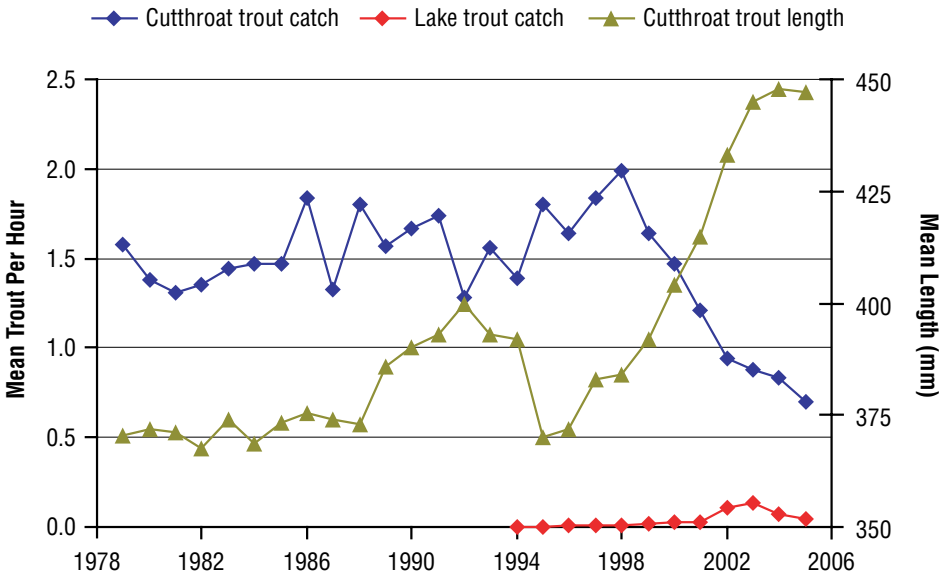


Figure 27. The 2005 angler-reported catch in Yellowstone Lake continued the trend of fewer but larger Yellowstone cutthroat trout, while the lake trout catch per hour decreased.

Public Involvement

Yellowstone Volunteer Flyfishing Program

Although Yellowstone's fisheries staff have directed much of their efforts at emerging crises such as lake trout removal and whirling disease in recent years, there are a multitude of other fisheries issues and questions that need attention. There are an estimated 2,650 miles of streams and 150 lakes with surface waters covering 5% of Yellowstone's 2.2 million total acres. Because NPS staff cannot address all of the park's aquatic issues, a program was established wherein flyfishing volunteers use catch-and-release angling as a capture technique for gathering biological information on fish populations throughout the park. In 2005, the Volunteer Flyfishing Program was coordinated by Dr. Timothy Bywater and Mr. Bill Voigt, both avid flyfishers and long-time supporters and promoters of Yellowstone's fisheries. Projects included determination of the range of hybridized Yellowstone cutthroat trout in the Lamar River, its major tributaries, and several other park waters; and documentation of the status and movement patterns of Arctic grayling in the Gibbon River system. Under this incredibly successful program, volunteer anglers from across the U.S. traveled to the park to participate as an active component of the Aquatics Section. Volunteers experienced many fisheries issues first-hand, and the biological data collected will contribute to understanding the park's fisheries.

NPS/TIMOTHY BYWATER

Coordinator Tim Bywater (third from left) leads volunteer anglers to destinations throughout the park.

Long-term Volunteer Assistance

The Aquatics Section recruits long-term (more than 12 weeks) volunteers from the Student Conservation Association and other sources (see Appendix iii). Volunteers stay in park housing at Lake, and work a full-time schedule similar to paid NPS seasonal staff. All aspects of the Aquatics Section greatly benefit from both long- and short-term volunteer support.

Educational Programs

Aquatics Section staff continued to provide a variety of short-term educational programs for visiting schools and other interested groups, with an emphasis on native fish conservation. The staff also provided American Red Cross certification in first aid and CPR for employees of YNP and other agencies.

Collaborative Research

The Yellowstone Center for Resources, through the Aquatics Section, provides both direct and indirect support for collaborative research with scientists at other institutions, primarily universities. These studies address some of the most pressing issues faced by NPS biologists and other regional managers of aquatic systems.

Projects by Graduate Students

Graduate student: Julie Alexander (Doctor of Philosophy candidate).
Committee co-chairs: Drs. Billie Kerans and Todd Koel, Department of Ecology, Montana State University.
Title: Detecting *Myxobolus cerebralis* infection in *Tubifex tubifex* of Pelican Creek, Yellowstone National Park.

Graduate student: Patricia Bigelow (Doctor of Philosophy candidate).
Committee chair: Dr. Wayne Hubert, U.S. Geological Survey, Wyoming Cooperative Fish and Wildlife Research Unit, Department

of Zoology and Physiology, University of Wyoming.
Title: Predicting suitable spawning areas and potential colonization by lake trout on Yellowstone Lake.

Graduate student: Brian Ertel (Master of Science candidate).
Committee chair: Dr. Thomas McMahon, Department of Ecology, Montana State University.
Title: Cutthroat trout life history strategies in the Yellowstone River upstream of Yellowstone Lake.

Graduate student: Lynn Kaeding (Doctor of Philosophy candidate).
Committee chair: Dr. Daniel Goodman, Department of Ecology, Montana State University.
Title: Comprehensive analysis of historic and contemporary data for the Yellowstone cutthroat trout population of Yellowstone Lake.

Graduate student: Silvia Murcia (Doctor of Philosophy candidate).
Committee co-chairs: Drs. Billie Kerans and Todd Koel, Department of Ecology, Montana State University.
Title: Relating *Myxobolus cerebralis* infection in native Yellowstone cutthroat trout (*Oncorhyncus clarki bouvieri*) with environmental gradients at three spawning tributaries to Yellowstone Lake in Yellowstone National Park.

Graduate student: Amber Steed (Master of Science candidate).
Committee co-chairs: Drs. Al Zale, U.S. Geological Survey Cooperative Fisheries Research Unit, and Todd Koel, Department of Ecology, Montana State University.
Title: Spatial dynamics of Arctic grayling in the Gibbon River, Yellowstone National Park.

Graduate student: Lusha Tronstad (Doctor of Philosophy candidate).
Committee chair: Dr. Robert Hall, Department of Zoology and Physiology, University of Wyoming.
Title: The ecosystem consequences of invasive lake trout in Yellowstone Lake and tributary streams.

Interagency Workgroups

Yellowstone National Park actively participates in the Yellowstone Cutthroat Trout Interstate Workgroup, the Montana Cutthroat Trout Steering Committee, and the Fluvial Arctic Grayling Workgroup. Shared goals and objectives among partner agencies and non-governmental organizations are defined in a memorandum of agreement for the rangewide conservation and management of Yellowstone cutthroat trout, a memorandum of understanding (MOU) and conservation agreement for westslope cutthroat trout and Yellowstone cutthroat trout in Montana, and an MOU concerning the recovery of fluvial Arctic grayling.

NPS/TIMOTHY BYWATER

Flyfishing volunteers collect information used for management of the park's fishery resources.

Cutthroat Trout Broodstock Development

Wyoming Game and Fish employees collect a limited number of Yellowstone cutthroat trout gametes from the Yellowstone River at LeHardys Rapids. Gametes are used for enhancement of the native Yellowstone cutthroat trout broodstock (now located at Ten Sleep, Wyoming) and restoration activities in Montana and Wyoming. As an added benefit for Yellowstone fisheries, each year, age-zero Yellowstone cutthroat trout from the broodstock (LeHardys Rapids origin) in Wyoming are returned to the park for whirling disease exposure studies.

Acknowledgments

Don Wethington operates the NPS gillnetting boat *Freedom* each day. Joe Facendola, Brad Olszewski, and Stacey Sigler have returned to Lake for many seasons. These individuals, as well as several other seasonal staff, have made significant contributions to our understanding of lake trout ecology and have been a driving force behind the suppression of these fish to preserve the Yellowstone Lake cutthroat trout.

Much-appreciated administrative support for the Aquatics Section was provided by Becky Wyman, Barbara Cline, Melissa McAdam, and Joy Perius, with special thanks to Mary McKinney for all of her assistance and patience when working with the fisheries staff at the Lake office.

The Aquatics Section is supported through Yellowstone Center for Resources base funding and by anglers visiting Yellowstone National Park (through a portion of the fees collected from the Fishing Special Use Permits each year). In 2004–2005, additional funding was received from the following sources:

- Yellowstone Park Foundation, through the Fisheries Fund Initiative and Volunteer Flyfishing Program
- Yellowstone Association
- National Partnership for the Management of Wild and Native Coldwater Fisheries, Whirling Disease Initiative
- National Park Service, Inventory and Monitoring Program, Vital Signs Monitoring Program
- National Park Service, Recreational Fee Demonstration Program
- Greater Yellowstone Coordinating Committee
- Federal Highway Administration, Park Roads and Parkways Program

NPS/MIKE RUHL

Fairies' Fall, Amethyst Creek.

We would like to extend special thanks to the Yellowstone Park Foundation board and staff, and to the many private individuals who have graciously provided support for our critical fisheries projects in the park. Chessie Thacher was especially instrumental in the development of the Fisheries Fund Initiative in 2005, and for that we are truly grateful. Special thanks also to Andy Dana and The Anglers Club of New York City for hosting the Yellowstone Fisheries event on February 8, 2005.

S. Thomas Olliff, Natural Resources Branch Chief; Wayne Brewster, Deputy Director; and John Varley, Director, Yellowstone Center for Resources, provided guidance and support for the Aquatics Program.

Lisa Graumlich and Diane Eagleson of the Big Sky Institute, Montana State University, have graciously provided much-needed staff support for the Fisheries Fund Initiative. This support made it possible to move aggressively forward with cutthroat trout restoration in the park.

Matt Campbell, Idaho Department of Fish and Game, Eagle Fish Health Laboratory, kindly provided analyses of westslope cutthroat trout genetics samples from Fan Creek and the unnamed Grayling Creek tributary. Dennis Shiozawa, Brigham Young University, has provided genetics analyses of Yellowstone cutthroat trout. Results of these analyses have been instrumental in the progress made toward restoration of these subspecies within the park.

Cathie Jean and the staff of the Greater Yellowstone Network have been instrumental in the development of and provided funding for the park's water quality monitoring program.

Crystal Hudson and the staff at the USFWS Bozeman Fish Health Center have provided the park with an incredible amount of critical information on the health of our native fish populations each year.

Special thanks to Cal Frasier of the Montana Water Center's Wild Trout Laboratory for years of support for our whirling disease research program. In 2005, Trey Kucherka also patiently provided care for exposed trout and made it possible for us to conduct avian piscivore feeding studies.

We also thank the many volunteers who have dedicated their time and a great deal of other expense to our Aquatics Section. Without them, much of what we do would not be possible. Flyfishing anglers from Trout Unlimited, the Federation of Fly Fishers, the Henry's Fork Foundation, and many other organizations in the region and throughout the United States contributed hundreds of hours of time and costs associated with travel to our Volunteer Flyfishing Program; for that, we are extremely grateful.

Many additional individuals from within Yellowstone National Park have contributed to the success of Aquatics Section activities; unfortunately, we cannot mention them all here. However, we would like to especially thank Dave Hill, Earl McKinney, Susan Ross, Bruce Sefton, Melinda Sefton, Art Truman, Mark Vallie, Lynn Webb, and Dave Whaley from Lake Maintenance; Rick Fey, Michael Keator, Dave Phillips, Brad Ross, Steve Swanke, Boone Vandzura, and Kim West from the South District Rangers; and Dave Elwood, Monte Simenson, and Wally Wines from Corral Operations.

This report is made possible only by the dedicated work of the Resource Information Team, Yellowstone Center for Resources. Special thanks to Tami Blackford, Virginia Warner, and Alice Wondrak Biel for making this report a reality.

NPS/JEFF ARNOLD

Water quality technician Jeremy Erickson and Student Conservation Association volunteer Matt Christianson sample Soda Butte Creek.

Literature Cited

Alexander, J., B. L. Kerans, and T. M. Koel. 2006. Assessment of *Tubifex tubifex* habitat and *Myxobolus cerebralis* distribution in Pelican Creek, Yellowstone National Park. Proceedings of the 12th annual international whirling disease symposium, February 9–10, 2006, Denver, Colorado.

Angermeier, P. L., A. P. Wheeler, and A. E. Rosenberger. 2004. A conceptual framework for assessing impacts of roads on aquatic biota. *Fisheries* 29(12):19–29.

Arnold, J. L., and T. M. Koel. 2006. Bioassessment and water quality sampling of Middle Creek and Mammoth Crystal Spring, Yellowstone National Park, Wyoming, 2002–2005. National Park Service, Yellowstone Center for Resources, Yellowstone National Park, Wyoming, YCR-2006-06.

Behnke, R. J. 2002. *Trout and salmon of North America*. New York: The Free Press.

Boutelle, F. A. 1889. Supplemental report of the Superintendent of the Yellowstone National Park. Washington, D.C.: U.S. Government Printing Office.

Gresswell, R. E., and J. D. Varley. 1988. Effects of a century of human influence on the cutthroat trout of Yellowstone Lake. American Fisheries Society Symposium 4:45–52.

Hall, R. O., J. L. Tank, and M. F. Dybdahl. 2003. Exotic snails dominate nitrogen and carbon cycling in a highly productive stream. *Frontiers in Ecology and the Environment* 1:407–411.

Hilsenhoff, W. L. 1987. An improved biotic index of organic stream pollution, *Great Lakes Entomologist* 20:31–39.

———. 1988. Rapid field assessment of organic pollution with a family-level biotic index. *Journal of the North American Benthological Society* 7:65–68.

Janetski, D. J. 2006. Genetic considerations for the conservation and management of Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*) in Yellowstone National Park. Masters thesis. Brigham Young University.

Jones, R. D., G. Boltz, D. G. Carty, L. R. Kaeding, D. L. Mahony, and S. T. Olliff. 1993. Fishery and aquatic management program in Yellowstone National Park. U.S. Fish and Wildlife Service, technical report 1992, Yellowstone National Park, Wyoming.

Jones, R. D., R. E. Gresswell, D. E. Jennings, D. C. Lentz, S. M. Rubrecht, J. S. VanDeventer, and J. D. Varley. 1979. Fishery and aquatic management program in Yellowstone National Park. U.S. Fish and Wildlife Service, technical report 1978, Yellowstone National Park, Wyoming.

Jordan, D. S. 1891. A reconnaissance of streams and lakes in Yellowstone National Park, Wyoming in the interest of the U.S. Fish Commission. *Bulletin of the U.S. Fish Commission* 9 (1889):41–63.

Kaya, C. M. 1992. Review of the decline and status of fluvial Arctic grayling in Montana. *Proceedings of the Montana Academy of Sciences* 52:43–70.

———. 2000. Arctic grayling in Yellowstone: Status, management, and recent restoration efforts. *Yellowstone Science* 8(3):12–17.

Kerans, B. L., M. F. Dybdahl, M. M. Gangloff, and J. E. Jannot. 2005. *Potamopyrgus antipodarum*: Distribution, density, and effects on native macroinvertebrate assemblages in the Greater Yellowstone Ecosystem. *Journal of the North American Benthological Society* 24:123–138.

Koel, T. M., J. L. Arnold, P. E. Bigelow, B. D. Ertel, and D. L. Mahony. 2003. Yellowstone Fisheries & Aquatic Sciences: Annual Report, 2002. National Park Service, Yellowstone Center for Resources, Yellowstone National Park, Wyoming, YCR-NR-2003-02.

Koel, T. M., and B. L. Kerans. 2004. *Myxobolus cerebralis* in a pristine environment: The role of American white pelicans as a dispersal vector in the Greater Yellowstone Ecosystem. Interim report submitted to the Whirling Disease Initiative, Montana Water Center, Bozeman, Montana.

Koel, T. M., J. L. Arnold, P. E. Bigelow, P. D. Doepke, B. D. Ertel, and D. L. Mahony. 2004. Yellowstone Fisheries & Aquatic Sciences: Annual Report, 2003. National Park Service, Yellowstone Center for

Resources, Yellowstone National Park, Wyoming, YCR-NR-2004-03.
Koel, T. M., J. L. Arnold, P. E. Bigelow, P. D. Doepke, B. D. Ertel, and D. L. Mahony. 2005a. Yellowstone Fisheries & Aquatic Sciences: Annual Report, 2004. National Park Service, Yellowstone Center for Resources, Yellowstone National Park, Wyoming, YCR-NR-2004-03.
Koel, T. M., P. E. Bigelow, P. D. Doepke, B. D. Ertel, and D. L. Mahony. 2005b. Non-native lake trout result in Yellowstone cutthroat trout decline and impacts to bears and anglers. *Fisheries* 30(11):10–19.
Koel, T. M., D. L. Mahony, K. L. Kinnan, C. Rasmussen, C. J. Hudson, S. Murcia, and B. L. Kerans. 2006a. *Myxobolus cerebralis* in native cutthroat trout of the Yellowstone Lake ecosystem. *Journal of Aquatic Animal Health* 18:157–175.
Koel, T. M., P. E. Bigelow, P. D. Doepke, B. D. Ertel, and D. L. Mahony. 2006b. Conserving Yellowstone cutthroat trout: Yellowstone's aquatic sciences program. *Yellowstone Science* 14(2):20–28.
Koel, T. M., and J. York. 2006. Restoration of westslope cutthroat trout in the East Fork Specimen Creek Watershed. Environmental Assessment. National Park Service, U.S. Department of the Interior, Yellowstone National Park. May 5, 2006. 82 pp. + appendices; Finding of no significant impact (FONSI). Restoration of westslope cutthroat trout in the East Fork Specimen Creek Watershed. Environmental Assessment. Yellowstone National Park, Idaho/Montana/Wyoming. Prepared by J. York and T. Koel. June 30, 2006. http://parkplanning.nps.gov.
Kulp, M. A., and S. E. Moore. 2005. A case history of fishing regulations in Great Smoky Mountains National Park: 1934–2004. *North American Journal of Fisheries Management* 25:510–524.
Lenz, B. N. 1997. Feasibility of combining two aquatic benthic macroinvertebrate community databases for water-quality assessment: U.S. Geological Survey Fact Sheet FS-132-97, 4pp.
Leopold, A. S., S. A. Cain, C. M. Cottam, I. N. Gabrielson, and T. L. Kimball. 1963. Wildlife management in the national parks. *Transactions of the North American Wildlife and Natural Resources Conference.* Volume 28.
May, B. E., W. Urie, and B. B. Shepard. 2001. Range-wide status of Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*): 2001. USDA Forest Service, Bozeman, Montana.
Montana Department of Environmental Quality (MDEQ). 2002 TMDL Report for Soda Butte Creek. http://maps2.nris.state.mt.us.
National Park Service. 2000. NPS management policies 2001. National Park Service, U.S. Department of the Interior. 137 pp.
Novak, M. A., J. L. Kershner, and K. E. Mock. 2005. Molecular genetic investigation of Yellowstone cutthroat trout and finespotted Snake River cutthroat trout: a report in partial fulfillment of State of Wyoming grant agreement #165/04. Utah State University. 66 pp.
Richards, D. C. 2002. The New Zealand mudsnail invades the western United States. *Aquatic Nuisance Species Digest* 4:42–44.
Ruhl, M., and T. M. Koel. 2005. Preliminary investigations of westslope cutthroat trout residing in an unnamed tributary of Grayling Creek. Report to the Montana Westslope Cutthroat Trout Workgroup. Fisheries and Aquatic Sciences Section, Center for Resources, Yellowstone National Park, Wyoming.
Ruzycki, J. R., D. A. Beauchamp, and D. L. Yule. 2003. Effects of introduced lake trout on native cutthroat trout in Yellowstone Lake. *Ecological Applications* 13:23–37.
Schullery, P. 1997. *Searching for Yellowstone: Ecology and wonder in the last wilderness*. New York: Houghton Mifflin Company, 338 pp.
Shuler, S. 1995. Soda Butte drainage reconnaissance fish survey 1994. Project completion report. Gardiner Ranger District, Gallatin National Forest.
U.S. Fish and Wildlife Service (USFWS). 1971. Fishery management program in Yellowstone National Park. Annual project report for 1970. Yellowstone National Park, Wyoming, 114 pp.

U.S. Geological Survey (USGS). 1999. Benthic invertebrates and quality of streambed sediments in the White River and selected tributaries in and near Indianapolis, Indiana, 1994–96. Water-Resources Investigations Report 99-4276.

Varley, J. D. 1979. Record of egg shipments from Yellowstone fishes, 1914–1955. Information paper no. 36. Yellowstone National Park. 45 pp.

———. 1981. A history of fish stocking activities in Yellowstone National Park between 1881 and 1980. Information paper No. 35. Yellowstone National Park. 94 pp.

Varley, J. D., and P. Schullery. 1998. *Yellowstone fishes: Ecology, history, and angling in the park*. Mechanicsburg, Pa.: Stackpole Books, 154 pp.

Wyoming Department of Environmental Quality (WDEQ). 2001. Water quality rules and regulation, chapter 1, Wyoming surface water quality standards. Water Quality Division, Water Quality Program, Cheyenne, Wyoming.

Yellowstone National Park (YNP). 2006. Fishing regulations. http://www.nps.gov/yell/planvisit/todo/fishing/index.htm.

Zale, A. V. 2003. Distribution, movements, and life history characteristics of genetically pure westslope cutthroat trout (*Oncorhynchus clarki lewisi*) in the Fan Creek drainage, Yellowstone National Park. Montana Cooperative Fishery Unit, Montana State University, Bozeman, Montana.

NPS/TIMOTHY BYWATER

Appendices

Appendix i. Fish Species List

Native (N) and introduced (non-native or exotic, I) fish species and subspecies known to exist in Yellowstone National Park waters including the upper Missouri (Missouri, Madison, and Gallatin rivers), Snake River (Snake), and Yellowstone River (Yell R.) drainages.

Family	Common Name	Scientific Name	Status	Missouri	Snake	Yell R.
Salmonidae	Yellowstone cutthroat trout	*Oncorhynchus clarki bouvieri*	Native	I	I	N
	westslope cutthroat trout	*Oncorhynchus clarki lewisi*	Native	N		
	finespotted Snake River cutthroat trout	*Oncorhynchus clarki behnkei**	Native		N	
	rainbow trout	*Oncorhynchus mykiss*	Non-native	I	I	I
	mountain whitefish	*Prosopium williamsoni*	Native	N	N	N
	brown trout	*Salmo trutta*	Exotic	I	I	I
	eastern brook trout	*Salvelinus fontinalis*	Non-native	I	I	I
	lake trout	*Salvelinus namaycush*	Non-native		I	I
	Arctic grayling	*Thymallus arcticus montanus*	Native	N		I
Catostomidae	Utah sucker	*Catostomus ardens*	Native		N	
	longnose sucker	*Catostomus catostomus*	Native			N
	mountain sucker	*Catostomus platyrhynchus*	Native	N	N	N
Cyprinidae	lake chub	*Couesius plumbeus*	Non-native			I
	Utah chub	*Gila atraria*	Native	I	N	
	longnose dace	*Rhinichthys cataractae*	Native	N	N	N
	speckled dace	*Rhinichthys osculus*	Native		N	
	redside shiner	*Richardsonius balteatus*	Native		N	I
Cottidae	mottled sculpin	*Cottus bairdi*	Native	N	N	N

*Scientific name suggested by Behnke (2002), *Trout and Salmon of North America* (New York: The Free Press), and not currently recognized by the American Fisheries Society.

Appendix ii. The Waters of Yellowstone (adapted from Varley and Schullery, 1998)

Size of the park	898,318 hectares
Water surface area	45,810 hectares (5% of park)
Number of lakes	150
Lake surface area total	43,706 hectares
Number of fishable lakes	45
Yellowstone Lake surface area	36,017 hectares
Number of streams	>500
Stream length total	4,265 kilometers
Stream surface area total	2,023 hectares
Number of fishable streams	>200

JORDAN ALLISON

Arctic grayling from the Gibbon River system.

NPS/PHILIP DOEPKE

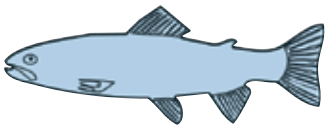
Fisheries volunteer Siana Wong with a record 22.5-pound non-native lake trout from Yellowstone Lake.

Appendix iii. Long-term Volunteers, 2005

Name
Allison, Jordan
Behncke, Jeff
Christianson, Matthew
Rudolph, Dominique
Talbott, Mariah
Tong, Amanda
Voigt, JoAnn
Wong, Siana

Appendix iv. Seasonal Staff, 2005

Name
Bywater, Timothy
Erickson, Jeremy
Facendola, Joseph
Hutchinson, Hunter
Legere, Nicole
Naughton, Joe
Olszewski, Brad
Romankiewicz, Christopher
Schamberry, Nicole
Sigler, Stacey
Varian, Anna
Voight, Bill
Wethington, Don



JORDAN ALLISON

Cache Lake, located at the headwaters of Reese Creek, has retained its historically fishless condition.

JOE FACENDOLA

Yellowstone cutthroat trout.