Wild Trout VIII

30th Anniversary

Working Together to Ensure the Future of Wild Trout

Old Faithful Lodge
Yellowstone National Park

September 20–22, 2004

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Proceedings of the Symposium

Old Faithful Lodge—Yellowstone National Park

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Steve Moore
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Wild Trout VIII

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Working Together to Ensure
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Wild Trout VIII—Working Together to Ensure the Future of Wild Trout

Steve Moore, Symposium Chair

Supervisory Fishery Biologist, Great Smoky Mountains National Park, Gatlinburg, Tennessee

Mention the words wild trout or Yellowstone to a cold-water fishery biologist or trout angler and immediately thoughts of beautiful scenery, wild unspoiled rivers, and elk and bison spring forth. In fact, throughout the last century Yellowstone National Park has been touted as one of the "must fish" destinations for avid wild trout anglers. Annually, thousands of anglers flock to the Park for the opportunity to fish for and hopefully catch wild and/or native trout. The wildness and beauty of Yellowstone make it easy to forget that the wild trout resources are faced with many threats. Unfortunately, as we learned in vivid detail, even in this "protected environment" native and wild trout are threatened by non-native trout and diseases. The solutions to the problems will be complex and will require people from many disciplines and many years of effort to resolve.

The theme of the conference was "Working Together to Ensure the Future of Wild Trout." The organizing committee selected this theme because as human population growth and urbanization encroaches into watersheds and sensitive headwater areas the need to protect these sensitive areas increases. During the conference, attendees learned how diverse groups had joined forces to protect and restore watersheds. In other cases, biologist and anglers had worked collaboratively to create a broad swath of interest and disciplines to insure a community based and holistic approach to land use and watershed health. Without a doubt, future partnerships for the protection of watershed health will be partnerships of "unlikes," people who have different views and perspectives about desirable outcomes than those of traditional biologists and anglers. Because biologist and anglers have not always had good working relationships with organizations that have a different perspective or goal, the order of the day will be collaboration. This process may not produce optimal solutions in the minds of some, but the probability of implementing actions to protect watershed health will be increased.

Attendees learned how agencies and user groups value and balance the management of native, introduced, and invasive species. Part of this discussion focused on the cost of native species restoration and challenged the group to weigh the long-term cost before implementing a restoration program. In some cases, public demand and advocacy for nonnative wild fish conflict with management agency missions to conserve wild native fish. A discussion of regulations and their utility for achieving management goals provided interesting insights. In some cases, the regulations failed to produce desirable outcomes because of the biology of the system while in others regulations were implemented based solely on the desires of the angling public. Ray White and Pete Van Gytenbeek were honored for their life long contributions to fishery science and to the protection of fishery resources and the education of the angling public. A first for Wild Trout was the presence of students from the Montana

State University student chapter of the, American Fisheries Society. Participants exchanged ideas with these bright budding biologists and provided them with insights related to their research and future employment opportunities. However, most importantly, as the 30-year history of Wild Trout was celebrated, we shared ideas, developed new friendships, and spent time with biologist, anglers, and conservationist discussing concerns and issues related to the future of wild trout.

As we prepare for Wild Trout IX in 2007, we need to take home the lessons learned from Wild Trout VIII and the last 30 years and implement them. The management of wild trout can no longer be viewed as the responsibility of agencies alone. Effective environmental management in the 21st century must focus on the interrelationships between land and water and water quality and quantity and the human population that derives benefits and value from aquatic resources. Our primary goal must be the protection and preservation of wild trout resources and wise environmental stewardship. As we develop strategies to meet that goal, we must involve all stakeholders. Fostering a sense of ownership and understanding must be the first step in long-term conservation planning.

Until 2007, keep pressing forward in your efforts to collect the information that will help protect wild trout. However, in the process, stay connected with family, friends, and professional acquaintances because they will keep you connected with things in life that are important. **Also, do not fail to find time to go to your favorite stream in search of wild trout.**

Wild Trout VIII—Welcoming Remarks

Frank Walker
Deputy Superintendent, Yellowstone National Park

It is my great pleasure to welcome you to Yellowstone this morning. I am sure that many in this room remember the late Jack Anderson, superintendent of Yellowstone in the 1970s. If you do, you must also remember his dedication to wild trout, to say nothing of his passion for fishing. I think it is safe to say that Jack would be thrilled to know that thirty years after he opened the first wild trout symposium here in Yellowstone, this series is still so very vital and important. Surely, he would also be delighted with the long, fruitful partnership between this symposium series and Yellowstone National Park.

So I would like to begin by congratulating you, and thanking you, on behalf of Yellowstone and all its friends, for your outstanding record of scientific publication, your creation of an enduring forum for the debate and conversation so essential in resource management, and your persistent championing of the cause of wild trout.

Thirty years is a long time—a career for most of us—and I know that many of you have been here since the beginning. You have sustained your passion for wild trout—and the wild places that sustain them—and will continue to do so long after this symposium ends on Wednesday.

In the life of this symposia series, you have witnessed or personally accomplished monumental advances in wild trout science and management. You've seen a huge shift toward public appreciation for wild trout, not only for sport fishing but also as a legitimate element of countless ecological communities. You've enabled the conservation and recovery of wild, native trout populations. In addition, you've faced the challenge of the many old and new problems besetting our aquatic resources, from angler overcrowding to whirling disease to exotic species invasions. You've given those of us who are manager's reason to hope that whatever threatens wild trout, there is a smart, energized community of specialists eager to find solutions.

I speak for many managers in many places when I tell you that those solutions are more urgently needed than they ever have been. Wild trout management is not for the faint of heart, or the easily discouraged. Before coming to Yellowstone, Superintendent Suzanne Lewis was superintendent of Glacier National Park, which, despite its rugged and remote wilderness setting, is now down to a single body of water that hosts its only native fish community. Every other water in the park has had that native purity compromised.

Here in Yellowstone, as many of you know lake trout, whirling disease, and drought have reduced the Yellowstone Lake cutthroat trout to population and recruitment levels not seen since we so carelessly overfished them in the 1950s and 1960s. The bright promise Jack Anderson justifiably saw in the future of the Yellowstone cutthroat trout thirty years ago is threatened in ways he couldn't have imagined. The New Zealand mudsnail is already established in Yellowstone, and a host of other invaders, such as the zebra mussel, bighead carp, and spiny waterflea, may be on their way. The Missouri River form of westslope cutthroat trout of Fan Creek, which we so gratefully thought were

genetically pure, are not, so it appears that Yellowstone may be without a source population for that unique subspecies. Fluvial Montana grayling, which Yellowstone first attempted to restore in the 1970s, remains an unfulfilled goal.

I know all of this sounds like an oppressive and disheartening situation, but let me tell you why I'm still so hopeful for wild trout in Yellowstone.

The first reason is what you will see if you spend a little time on the roads and trails of this magnificent park. In so many ways, we have learned from past mistakes, and we have righted past wrongs. The wolves that you may very well hear howling, or even see hunting, are formidable proof of the ability of determined, far-sighted people to right such wrongs.

So are the populations of bison, elk, mountain lions, peregrine falcons, and other species, now restored from the misguided "best intentions" of earlier generations. So are the young forests you will see thriving in the many burns of the past thirty-years. Our natural fire policy is another powerful legacy of Jack Anderson's administration.

However, the good news out there on the landscape is not merely a matter of the health of this or that wildlife population. Our historical specialists tell us that the acreage of Yellowstone currently under the human footprint is at its smallest size since the 1920s. We are 132 years into learning how to care for this place, and we just keep getting better at it, and more faithful to Yellowstone's ecological integrity. I don't see any sign that we'll stop learning and improving, or that we'll ever know it all. We're not even close, but we're getting somewhere, and it shows.

The second reason I am hopeful for wild trout has directly to do with you. You folks symbolize all the people who care about Yellowstone's aquatic resources and in the long haul of Yellowstone history, those people have distinguished themselves as perhaps the park's most engaged constituency. I agree with the writer Thomas McGuane, who, when speaking at Wild Trout Seven, said, "I have come to think that our hope is the comradeship between all the players who have the well being of our waters at heart." Yellowstone's past experience suggests that Mr. McGuane has good reason to harbor such hope.

Here's a bold generalization I'd like you to think about. Yellowstone's aquatic resources have been the ones that most directly and personally engaged the ideas, opinions, and energy of the park's visitors and friends. Fishing is rare as a hands-on experience of Yellowstone's wild inhabitants. Not everybody approves of that, but it has undeniable advantages for the trout. Fishing has given many generations of visitors a deep and lasting stake in Yellowstone. At the same time, fishing gives managers a concrete way of connecting with those visitors. Thanks to many years of volunteer fisherman reports, Yellowstone's managers have been provided with several orders of magnitude more knowledge of how visitors feel about wild trout and fisheries management than we have ever had about any other aspect of Yellowstone's natural setting or its management programs.

There have been many telling examples of the power of this public relationship with Yellowstone's wild trout. About twenty years ago, when non-native brook trout were discovered in Arnica Creek, a small tributary of

Yellowstone Lake, the angling and trout conservation community was quick to mobilize, not only to alert the public to the crisis, but also to endorse and support our successful efforts to forestall a disastrous invasion. Now that we're in the midst of another disastrous invasion, this time by lake trout, the support of that same constituency has been just as heartening, and just as essential.

I am the first to admit that any Yellowstone issue, whether it involves our charismatic megafauna and microfauna, our flammable forests, our thousand historic structures, or any other treasure, can always draw a crowd and make the front page. However, I maintain that there is something about wild trout that brings to Yellowstone a different kind of passion—more immediately helpful and constructive, and more enduring. I see that Todd Koel and Tim Bywater are giving a talk on the park's Volunteer Angler Program at this conference. If you want a great example of what I'm talking about here, you mustn't miss that talk. Many of you who cannot spare the time to come and volunteer with our Fisheries program have supported it nonetheless, by supporting the fundraising efforts that Yellowstone Park Foundation is undertaking on behalf of wild trout. I want to recognize and thank you this morning.

It is that passion for trout, a passion that I personally share, I might add, and everything to do with them. A passion composed of equal parts comradeship, hope, and wisdom that will ensure the future of wild trout in Yellowstone. So move forward this week. Celebrate. Discuss. Argue. Bring your knowledge to the table. Come back soon and often. Bring your own passion. Wild trout cannot survive without you.

Wild Trout VIII – Conference Summary

R.W. Wiley

Retired Fisheries Biologist, Wyoming Game and Fish Department, Laramie, Wyoming

Wild Trout VIII with its varied program, well-spoken oral presentations, thought provoking poster displays on several facets of fisheries management, informative keynote address, and light, humorous, post-supper entertainment ranks as one of the best conferences over the 30-year history of Yellowstone-based wild trout gatherings. Conference organizers should be satisfied that a good program resulted from their work. The challenge of how to attract more resource user participation remains for those who will guide Wild Trout IX; on the other hand, maybe anglers and others interested in fisheries resources see a bright future for wild trout and thus have other more pressing pursuits.

Just before the conference began, I read the photo caption on a postcard addressed to a granddaughter, learning that bison, the largest mammals in North America, had been pushed to near extinction as a result of being poached and hunted for their hides and meat. By 1902, only 23 were counted in Yellowstone – the only remaining wild herd left in the United States. As a direct result of their near extinction, Congress enacted a law in 1894 that prohibited hunting in national parks. I think we are doing far better with native fish, including wild trout, management.

Points to Ponder

1) Conservation agencies cannot escape their responsibility for public perception of the quality of the angling experience because their actions largely created it (Clawson 1963). A quote from Wild Trout VII is well worth more reflection. We fisheries biologists have created many trends in angler use by management applications we have initiated.

2) Mastheads of the Sport Fishing Institute (SFI). During the 1960s, the masthead on the SFI Bulletin proclaimed the mission to be *to shorten the time between bites.* This was the commodity aspect of fisheries management. By the 1980s the message read, *the quality of fishing reflects the quality of living,* a change emphasizing the recreational aspect of fisheries management. Today, many anglers practice voluntary catch and release, suggesting that catching fish and returning them has become more important that catching and keeping them.

3) Our charge as fisheries resource managers is fishery resource stewardship, including wild trout, native trout, other game fish, and companion species. We are not simply shepherds of sport fishes.

The Conference Begins

We heard from Frank Walker that we are persistent champions of wild trout and Pete VanGytenbeek encouraged us to continue flying the wild trout flag. How are we doing? Despite a few setbacks such as lake trout *Salvelinus namaycush* in Yellowstone Lake and some unwanted invaders like the New Zealand mudsnail, native and wild trout have a bright future.

Keynote Address

Ted Turner said that society must combat climate change, reduce dependence on fossil fuels and appoint the best people as leaders. You may be a good leader if you:

- Let those you lead know and understand your resource ideals, goals, and expectations.
- Display integrity – do what you say you will do by the time you say it will be done,
- Know right from wrong,
- Champion your people,
- Are responsible and accountable for your own actions,
- Have enough sense to listen to and learn from your staff.

Highlights of the Sessions

Watershed-scale Approaches to Enhancing Trout Habitat and Reducing non-point Source Pollution.

Habitat and fish cannot be managed separately; fish and their habitat are inseparable. Fisheries managers and habitat specialists must work together to insure the future of trout fisheries. Too often conservation agencies have created independent habitat and fisheries management sections leading to independent fisheries management and habitat missions. A resource dependent on both services may fare poorly if habitat and fisheries management services work independently.

Effectively achieving the goals of watershed-based fisheries work requires partnerships among resource interests – all entities working in a watershed. For example, timber, livestock, mining, recreation, including fisheries, must communicate effectively for best management in a watershed. No single watershed interest can be maximized to the exclusion of another companion interest, but each interest can receive, at least, some satisfaction. As with any endeavor, the start may be slow and results may be a trickle initially. Do not forget that a mighty river has a small beginning.

For success of watershed-scale programs:

- Understand the people aspect of working together,

- Form constructive relationships with common values, commit time and resources, and share the credit,
- Coordinate effectively,
- Talk to people, even those that may be difficult, to seek understanding. Do not reject difficult people out of hand because a teaching or learning experience could be lost.

Communicating Fishery Science to the Public

We must champion the fish we have discussed during this and other conferences. If we do not lead, who will? An informed public is a supportive ally. Do not let lobbyists, developers and some exploitive special interests represent the resource without, at least, trying to inform them about the actual fisheries resource issues and values.

Make a lapidary epigram of Spencer Turner's suggestions for effectively writing about fisheries resources, including wild trout.

- Write actively – third person prose makes people yawn.
- Learn to understand popular writing. Submitting articles for editing, rewriting and submitting again is one effective way to learn. Editors are helpful but their suggestions can seem cold and sometimes harsh, but that is part of the learning process.
- Use humor when possible,
- Read your prospective articles aloud, be your own critic.

Fisheries biologists must fine-tune their bio-scientific fishery resource viewpoint with their anglers-eye perspective. Every good fishery biologist should be a sometime angler. Fishing adds a large fund of information about fish, their habits and habitat, otherwise unavailable to a fisheries biologist who does not fish. Besides, sharing angling-based viewpoints with the fishing public is a wonderful way to relate to resource users.

Balancing Management of Native, Introduced, and Invasive Species

Anglers are often very interested in fishing for introduced trout. We should not be surprised because our fisheries management actions created much of the interest. For example, during the formative years (1880-1940) of Wyoming fisheries management, trout and other game fish were stocked in any waters that appeared suitable for fish and many of the new fisheries were sustained by introduced species. Anglers enthusiastically pursued the new fishing opportunities even though some introduced trout replaced native species. Now fisheries managers try to restore native trout stocks wherever possible.

Costs of restoring populations of native trout are substantial. To determine where reintroductions may best be successful, we must first try to understand habitat condition when native trout flourished and then understand systems as they are now; the free flowing reaches, the impoundments and their tailwaters, irrigation and other water uses, the role of wild and hatchery-reared trout in sustaining fisheries, current habitat condition, and the remaining populations of native trout. Only then can reintroduction proceed towards a predetermined and realistic level of occupation of historic range.

In addition, we must remember and remind those who may forget that habitat may be so altered from times when native species flourished that successful reintroduction may be impossible. In addition, introduced species may be so well established and so well accepted by society as to render successful removal of the non-native species and reintroduction of the native improbable.

Regulations: Reality versus Expectations

Anglers sometimes report that fishing is not as good as it once was. Memory of past fishing successes is often brighter than memory of times when fishing was slow. Fishing regulations are often proposed to improve purportedly depressed angling success. Regulations can be successful only when changes in fishing are a result of fishing effort.

Fishing regulations can create trends and expectations among anglers. These are manageable when fisheries biologists are proactive rather than reactive; when our minds are open to new ideas, not anchored in tradition; and when we understand our clientele (anglers) and the fish.

Contributed Papers

Fish live where they do because of hereditary, ecological, and environmental influences (Ricker 1972). This idea helps understand why fish reared in different conditions may survive differently following stocking. Reintroduction of native trout species can be accomplished by using hatchery-reared trout or by transplanting from other native trout populations. Matching hatchery-reared trout as closely as possible to receiving water conditions makes use of the hatchery product more effective. Use of transplanted native trout to re-establish populations is more effective when the donor stream is in the same drainage because similar environmental conditions are more likely than when fish are moved from a stream in a different drainage system (Ricker 1972).

Resourceful fisheries biologists have shown that liming remains an effective tool for mitigating the impacts of acid precipitation on trout populations as demonstrated on the St. Mary's River, Virginia. Reported success notwithstanding, dealing with the acid precipitation problem at the source could be more effective in the long term but probably less popular because difficult societal decisions would be required – a challenge for the future.

Fisheries resource managers must be ever sensitive to keeping the publics trust because restoring trust lost is very difficult. Three important principles in maintaining public trust are:

- Be fair – offer realistic opportunity for public participation in resource management decisions that affect their use of the fishery resource,
- Be open – share fisheries information with all interests,
- Be honest – explain the decision process plus what can and cannot be done and avoid telling the public what you think they want to hear.

Finally, the Organizing and Program Committees for Wild Trout VIII deserve special thanks for producing one of the better programs in the 30-year history of wild trout conferences.

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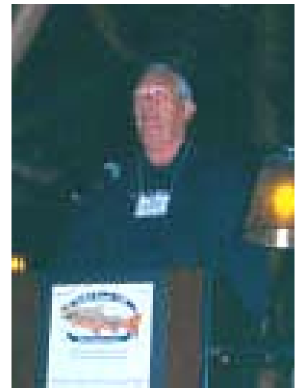
In the Beginning



Peter VanGytenbeek
Federation of Fly Fishers, Seattle, Washington

To fully appreciate the Wild Trout Symposia one must understand the state of fishery science and the public's perception and acceptance of it during the period before the first symposium in 1974. After World War 2 and Korea, the country was confident, prosperous and focused on building wealth and family. Certainly, the cold war was of concern but it did not deter us from enjoying our hard won prosperity. Hunting and fishing were very popular and as much as our fish and game had been given a pass during the war years, abundance and success were high. Yet, by the end of the fifties, signs of stress on wild populations were obvious to any reasonably trained observer. Water pollution, especially of fresh water streams, was becoming a serious problem.

Catch and kill regulations on streams and lakes accessible to growing urban populations were disseminating wild salmonid populations. Not to worry fisheries managers assured us, just like WW2 we could produce ourselves out of the problem. And produce we did.

In my home state of New Jersey, the Hackettstown hatchery was nationally renowned for its tremendous productivity and efficiency. Managers even bred a golden trout (actually a pale rainbow) to spruce up its product line. Inadvertently it also created a completely new breed of "sportsman" whose intelligence system told them when a fish truck left the hatchery and where it was headed. These in-the-know anglers would converge on the truck's route follow it to its destination and harvest obscene numbers of the confused critters almost as they came down the chute. Occasionally quick to respond to a problem the state quickly outlawed the fish convoys. The sportsmen were undeterred until one day a state trooper, having worked his way to the front of a major convoy and called for back up, closed the highway, and wrote an astounding 280 plus tickets.

Well it wasn't all that bad but you get the picture.

By the late fifties and into the early sixties there were signs of change. TU was formed in late '58 in hopes that it could do for the cold-water fishery what DU was doing for waterfowl. Thoughtful writers like Lee Wulff, Joe Brooks, AJ McCain, Ernie Schweibert, and Lefty Kreh were calling for limited kill, hook, and release and speaking of the critical importance of wild fish. Rachael Carson published her book SILENT SPRING and the battle over pesticides was joined. David Brower's Sierra Club had taken on the dam builders over a plan to dam the Grand Canyon. Fly Fishers from New York to Washington State joined together in '65 to form their federation. And one of the most fortuitous of all events took place . . . Cleveland's Cuyahoga River actually caught fire and generated a storm of publicity.

It was against this backdrop that the newly elected Nixon administration took the reins of government in Jan of '69. Along with the Kissinger's and McNamara's came Rogers Morton to head Interior. And Sec. Morton tapped a lanky Floridian to be his Asst. Sec. for Fish Wildlife and Parks, Nat Reed.

And good things happened fast. EPA, the Endangered Species Act, The Clean Water and Clean Air Acts and Wild and Scenic Rivers to name a few.

So now everything was fixed or about to be. Right? Well not exactly . . .

For example, in 1971 TU held a public program in Portland, OR. One segment was on hatchery operations and what should be done to improve them. Top scientists and interested private citizens from the US and Canada participated. Charles Lovell, U.S.F.S., Ben Schley, U.S. Fish and Wildlife Services hatcheries manager, Dr. Bus Grove from Penn State, Roderick Haig Brown and Starker Leopold among others.

One area of agreement was that the one size fits all approach then being practiced for anadramous fish was a serious error and that the practice should be immediately changed to use only fish stocks from the watersheds into which they were to be stocked. In the year 2000 The Hatchery Reform act was passed finally putting in law most of the recommendations from the ’71 meeting. Now if we can free up the funds the redesign and changed protocols may soon be in place after ONLY 30 plus years.

During this same time, I had the honor of managing TU as its first full time Executive Director. One of my duties was to accompany various state TU groups as they pleaded our case for wild trout, limited kill, and other special regulations before state agencies and commissions. I know now how the first extra terrestrial will feel as he attempts to explain himself to some governmental board. I had just delivered what I thought was a particularly convincing presentation on the need and logic for catch and release to a fish and wildlife Commission. Confident to a fault, I asked for questions. One of the commissioners raised his hand and asked, “Why the hell would anyone bother to go fishing if you aren’t going to eat the Damn things.”

We were making some progress but most new or changed regulations were the result of political pressure rather than a change in management philosophy.

Then in 1971, Jim Vincent published his blockbuster study on the effects of stocking hatchery trout on top of a wild trout population in the Madison River. In a nutshell, it was detrimental to both populations. This was a huge tool for TU, the FFF, and all those who were advocating for wild salmonids. Yet over the next year as I traveled the country I was appalled, at how few of the fisheries professionals with whom I talked had heard of Vincent’s study.

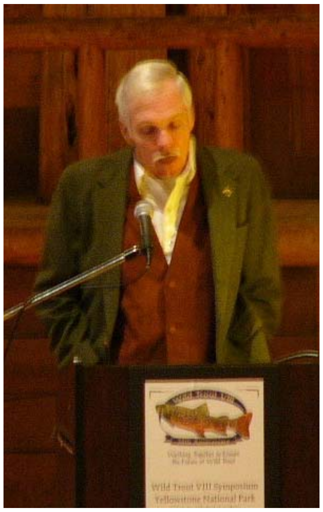
During that same period John Peters of the Forest Service and Frank Richardson of USF&W, and I, used to get together for lunch and to solve the countries environmental problems (at least to our satisfaction). One day I was complaining bitterly about the lack of dissemination of this study and one of us had the bright idea for a national symposium that would bring the top people in the field together to discuss the state of the science and then see that it was widely broadcast. During the next few weeks, we continued to embellish our idea until we thought it was ready for other eyes. We knew that the symposium would require prestigious sponsors in order to draw the best professionals. We also reasoned that the citizen conservation groups had to be involved in order to promote their visions and, perhaps more importantly, to receive and help disseminate the latest science to their organizations. Certainly, if we could get the citizen groups and the professionals on the same page much could be accomplished. Finally, professionally edited proceedings, printed in quantity and quickly disseminated along with venue with draw appeal would be required. Frank took the idea to Sec Reed who enlisted Sec Morton's support and that of TU, the Forest Service, and the FFF as co sponsors. There wasn't a lot of discussion about where our symposium should be held. Superintendent Jack Anderson had recently made Yellowstone hook and release only and closed fishing at fishing bridge…. and Sec. Reed controlled the venue. September of 1974 and Mammoth were selected as time and place And as they say the rest is history. In retrospect, it all went together so smoothly and quickly, I suspect that Frank had the wheels greased before he took our idea forward.

I attended the first three symposia and have read the proceedings from others. In great part, the Wild Trout Symposia have met the founder's goals and objectives. As an example one may look at the combined professional/citizen response to invasive species such as whirling disease, zebra mussels and more recently the New Zealand Mud Snail. Good science, quickly disseminated with rapid acceptance by the public coupled with coordinated action has greatly mitigated these threats to the fishery.

As I have become reacquainted with Wild Trout I do have a word of caution. In the words of a famous comedian, we run the risk of becoming "old hat." We are not "new." We live in a society that demands new and exciting and that constantly must be resold. We must market the importance of the symposia as we go forward as the important event that it is….to the public, to our professional base and to our sponsors. Do that and Wild Trout will continue the important task that its founders envisioned. It should, and must continue!

Keynote Address

Ted Turner



It is a pleasure to be here today. Let me begin by saying that everything I have learned in my life, I have learned on my own. I grew up in the southeast and learned to fish at the early age of 50. Since then I have been fascinated by the idea of catch and release. I am also interested in the topic of stream enhancement. On a national and global perspective, I have to share with you a bumper sticker that says it all: "save the humans."

My perspective on environmental degradation and nuclear weapons is to get rid of them. Nuclear threat initiatives need to be eliminated and we all need to work together to make things better.

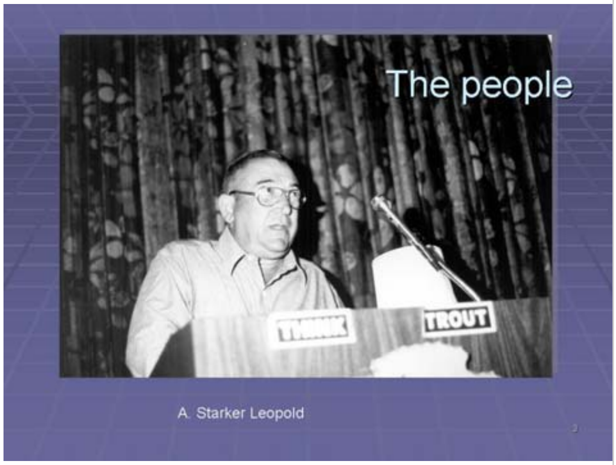
As for fossil fuel? I promote the use of windmills and solar panels. Good progressive leadership is essential to make this all happen. War is not a game.

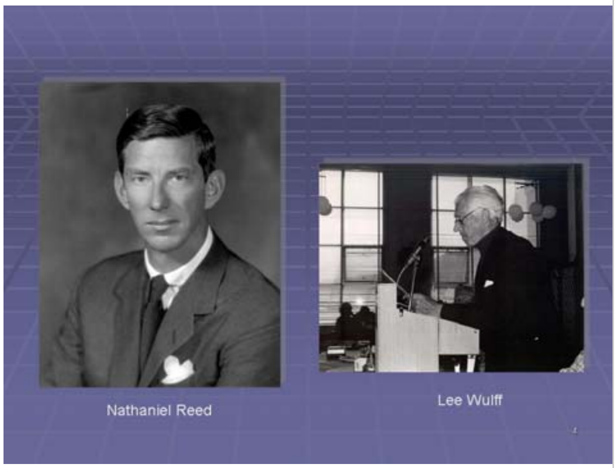
Question: What are your thoughts on restoration of native fish?
Answer: We need to remove non-native fish and replace with native fish.
Question: Why is there so little attention in the United States about global warming?
Answer: Administration has covered it up. Magazines like Fortune, Bass Week, and National Geographic have great articles on this subject.
Question: Do you think the problems of the world boil down to people?
Answer: The rise in population over the past 60 years means that we cannot continue to mitigate by using less.
Question: Partnerships – challenge to WT8 is to form partnerships to work toward protecting wild trout in the future. What is your opinion on this?
Answer: Gather together, donate money, give your time, do whatever you can when you can.
Question: What do you see as man's goal in the environment?
Answer: 15 years ago and 10 volumes of initiatives of the 10 commandments, I see that we must complete our seize on the environment and stop encroaching on any natural environment that exist. Careful study (extensive) must be ongoing on urban sprawl and growth. We must enforce development to go in areas already developed. Our goal should be to return property back into wild and natural state.
Question: Do you see a problem with storm water management?
Answer: I suggest that we irrigate as little as possible and leave water for stream flow.

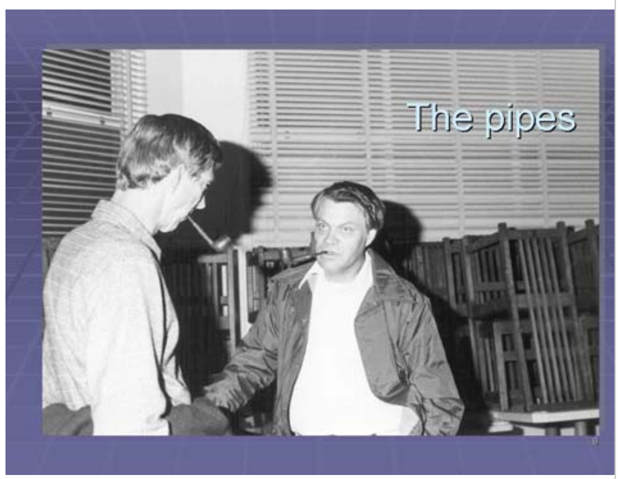
30th Anniversary of Wild Trout

Luncheon PowerPoint Presentation by Frank Richardson

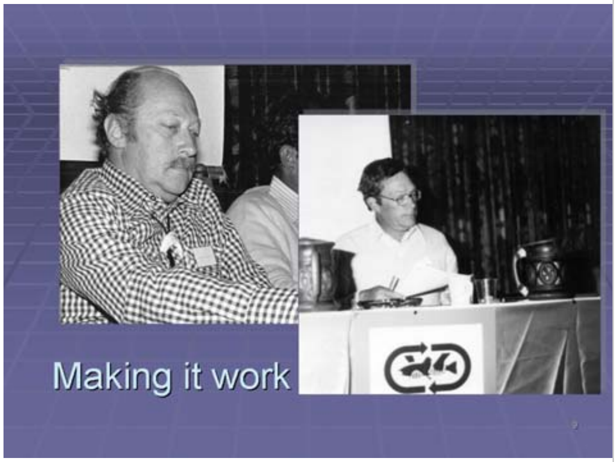
Luncheon—Speaker: Frank Richardson on the 30th Anniversary of Wild Trout

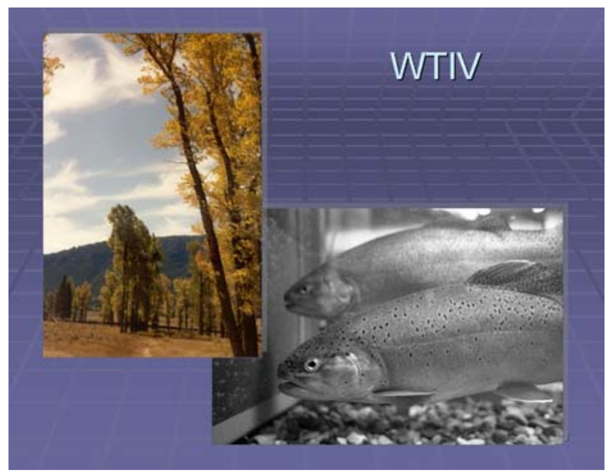


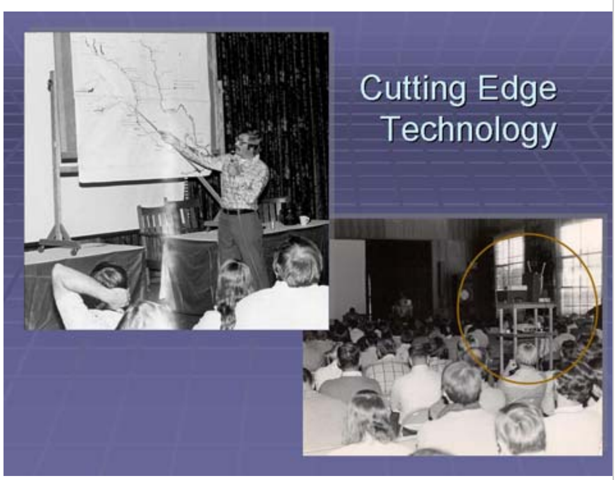




Luncheon—Speaker: Frank Richardson on the 30th Anniversary of Wild Trout







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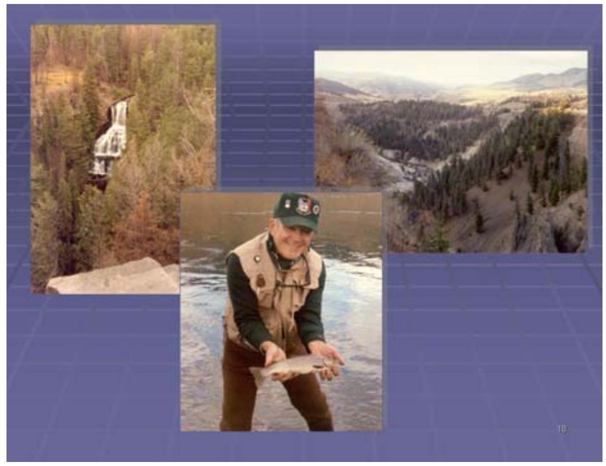

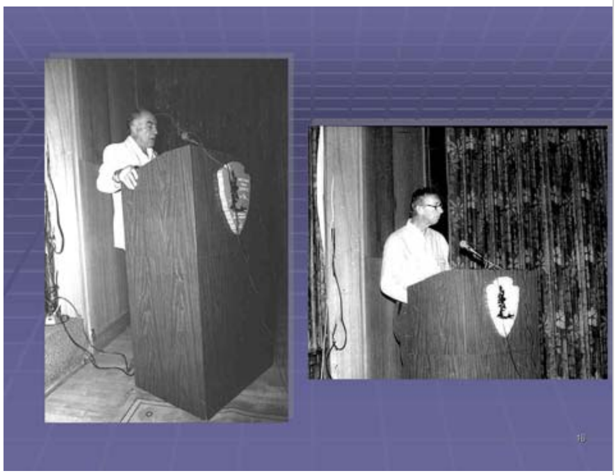

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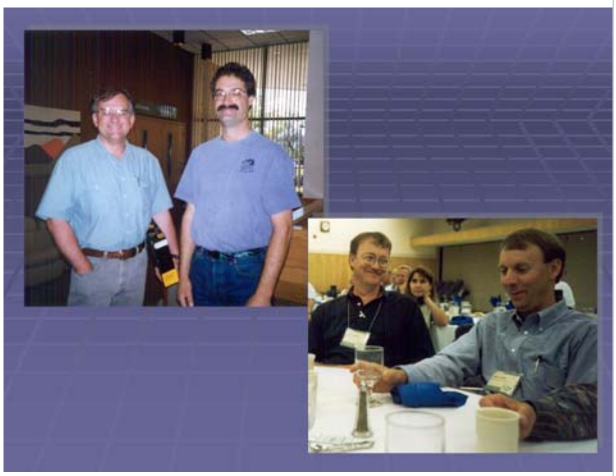

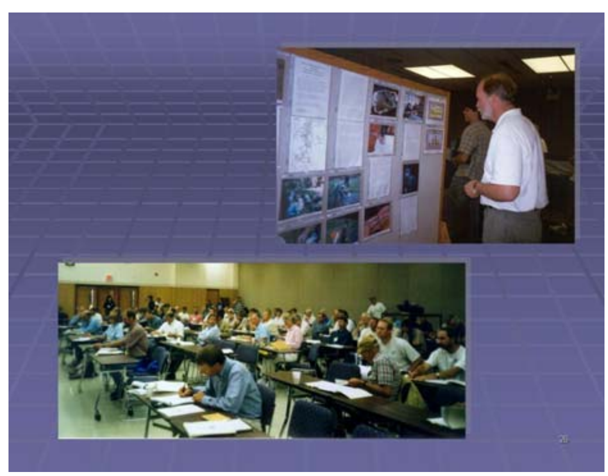

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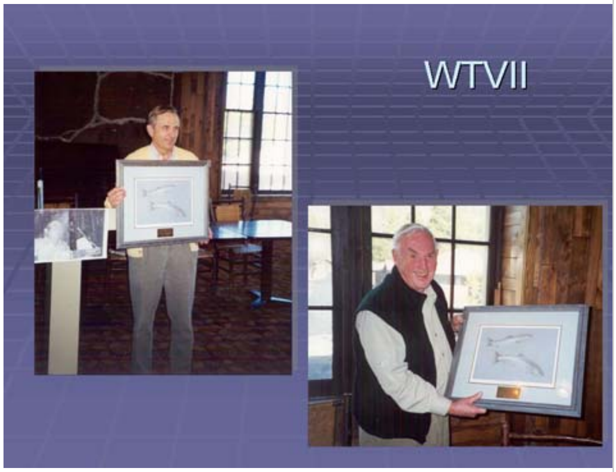
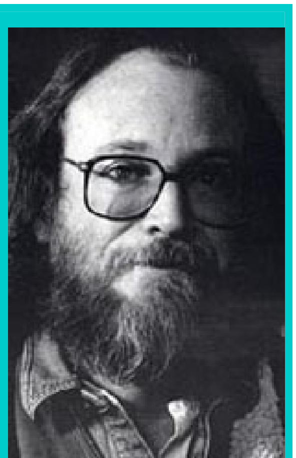


Banquet—Featuring Artist, Musician, Humorist, and Author Greg Keeler

Greg Keeler



In 1975 Greg Keeler started teaching English at Montana State University in Bozeman, where he became friends with Richard Brautigan, who was then a visiting professor at MSU.

In addition to teaching, Keeler is known for his collections of poems about fishing Montana rivers, American Falls and Epiphany at Goofy's Gas, and for his satirical songs about contemporary life.

Greg Keeler's webpage has a section dedicated to Richard Brautigan. The following material can be found at this site:

- The Ghost Of Richard Brautigan on Trail Creek (poem)
- Remembrances Of Richard Brautigan By His Friend Greg Keeler
- 10 Letters from Richard Brautigan to Greg Keeler 1983-1984

In 1985 Keeler wrote a story about Richard Brautigan, which appeared in Rolling Stock magazine. Apparently, this story included the letters that can be found on Keeler's website. If you have a copy of the issue of Rolling Stock that includes Keeler's story, please contact me.

More information on Greg Keeler can be found at the following sites:

- Greg Keeler plays Trout Ball
- MSU's Keeler Hooks Audiences with His Wit

Awards Luncheon—2004 WT VIII
A. Starker Leopold Wild Trout Awards

Marty Seldon, Chairman
Federation of Fly Fishers, Sunnyvale, California

Starker Leopold, world-renowned scientist, dedicated teacher, distinguished author, outstanding naturalist, beloved angling companion to many, and an influential speaker and participant at both Wild Trout I and II died on August 23, 1983. His death occurred a year before Wild Trout III at his home near the University of California Berkeley campus where he taught and was the retired head of the Zoology Department. Many of us still miss him and his counsel.

At the suggestion of Nathaniel P. Reed, former Assistant Secretary of the Interior, the federal official that first approved these Symposiums, the Sponsoring Committee established The Aldo Starker Leopold Wild Trout Award as a memorial to Starker in 1984.

A. Starker Leopold was born in Burlington, Iowa the eldest son of Aldo Leopold. Following in his father's footsteps, he became one of the worlds most influential and honored authorities on wildlife ecology and management. He attended the University of Wisconsin, Yale Forestry School, received his Ph.D. from the University of California at Berkeley in 1944 and retired there as Emeritus Professor of Biology in 1978.

Starker Leopold was heavily involved in public policy at the highest levels. In 1968 he chaired the Special Advisory Board on Wildlife Management of the Department of the Interior that led to significantly new national park and refuge policies. He was a member of the Advisory Committee on Predator Control and an international consultant on wildlife conservation policy. He served as a Director and President of the California Academy of Sciences, as a Director and Vice President of the Sierra Club and engaged in a broad range of public service activities.

Leopold addressed the negative impacts of multiple use at Wild Trout I. At Wild Trout II he spoke about degraded wild trout populations and the need to give higher priority to land use patterns and the physical condition of our lakes and streams. The following year Starker told the Federation of Fly Fishers annual convention, "For my part, I believe that the limited budget available for trout management is largely misspent on trivial activities, of no present value, such as the catchable trout program. Unless we bite the bullet and attack the habitat problem with vigor, the future of quality trout fishing in America is unpromising."

Starker's main goal was a world suited to wildlife and therefore fit for people. His personality was characterized by eminent academic and scientific achievements, love of the outdoors, positive personal warmth, and sensitivity. A. Starker Leopold was a friend to fish and wildlife, and to all of us.

As a continuing memorial these awards are given at each Symposium to a professional and a nonprofessional who over time have made significant contributions to the enhancement, protection, and preservation of wild trout in North American. Prior to each symposium, nominations are solicited from the sponsoring organizations, biologists, administrators, and conservationists that attend these wild trout symposiums.

The first A. Starker Leopold Wild Trout Awards were made at Wild Trout III in September 1984 to Martin M. Seldon, a long-time fisherman-conservationist, Sunnyvale, California and to Dr. Robert J. Behnke, Colorado State University, Fort Collins, Colorado, a noted trout biologist. The 1989 awards were made to Otto H. Teller, past President of Trout Unlimited, Glen Ellen, California and to Frank Richardson Lithonia, Georgia, retired U.S. Fish and Wildlife Service Assistant Regional Director and one of the initiators of these wild trout symposiums.

The 1994 A. Starker Leopold Awards at Wild Trout V were made to Gardner Grant, past President of the Federation of Fly Fishers and one of the initial organizers of these symposiums and to Ronald D. Jones retired U.S. Fish and Wildlife Service, Project Leader of the

Fisheries Assistance Office at Yellowstone National Park, Wyoming. At Wild Trout VI in 1997 respected author and wild trout researcher Ernie Schwiebert was honored in the nonprofessional category and several-time Symposium Chairman Roger Barnhart received the Award in the professional category. We believe you will agree with the Awards Committee that the honorees at Wild Trout VII meet the high standards called for in the selection process.

In October 2000, the WT-VII A. Starker Leopold Award went to Robert. L. Hunt. Mr. Hunt was part of the Wisconsin Department of Natural Resources for 33 years, retiring as Leader of the Cold Water Research Group. Bob has been an active Wild Trout Symposium participant calling for more rational programs to manage wild trout, involvement in the biopolitical process, and the initiation of new wild trout research projects. His career researched ecology, habitat relations, stream restoration, and the management of wild trout populations. Mr. Hunt had received countless honors and awards and has over 46 articles and a book to his credit.

The Wild Trout VII A. Starker Leopold Award in the nonprofessional category went to Bud Lilly a fourth-generation Montanan who became a celebrated fly-fishing guide, teacher, outfitter, and fisheries conservationist. Bud founded the Bud Lilly Fly Shop in West Yellowstone, was the first president of the Trout Unlimited chapter in Montana. And a charter member of the Federation of Fly Fishers and the first curator of the FFF International Fly Fishing Center. Bud is recognized as one of the most important Montana trout conservationists.

During the nomination and selection process for WT-VIII, our 30th anniversary, the Awards Committee agreed that we should return to the original concept of the award as the A. Starker Leopold Medal. The medal is three inches in diameter, made of solid brass with an antique bronze finish, and appropriate lettering. A profile of Starker, being drawn by Ernie Schwiebert, will be on one side of the medal and Awardee information on the other. Funding requests were made to allow us to strike the medal and one of our WT-VIII fish and wildlife telemetry systems exhibitors, Richard and Laura Reichle, Advanced Telemetry Systems. Inc. (www.atstrack.com) has made a very welcome company grant of $3,800 to carry out the project.

After completion of the nomination process and by vote of the committee, the 2004 WTV III A. Starker Leopold Awards were presented to:

Ray J. White, Professional Level

This year's awardee began his professional career as an Aquatic Biologist, Wisconsin Conservation Department, was a Visiting Scientist, Austrian Federal Institute of Waters Survey and Fishery Management. He was an Instructor, Institute of Hydrobiology and Fishery Science, University of Hamburg, W. Germany, a Graduate Research Asst. University of Wisconsin, and a Postdoctoral Research Associate. He became an Associate Professor Fisheries and Wildlife, Michigan State University and in 1990 retired as an Associate Professor of Fishery Science, Montana State University.

Dr. White presently has a private consulting firm, Trout Habitat Specialists, Redmond, Washington. Ray J. White is a consultant whose time, service, and advice continues to guide fishery conservation groups and international agencies.

Ray While Received a B.A. 1957 and M.S. 1964, Zoology, University of Wisconsin. He continued in graduate studies in Hydrobiology/Fishery Science 1966-68, at the University of Hamburg, Germany and received his Ph.D. Zoology on 1972, University of Wisconsin and then did continuing studies in Germany.

He is a long time advisor to Trout Unlimited, and many others including the Yakima River Alliance and the Federation of Fly Fishers Steelhead Committee. Ray is a member of a broad range of panels, committees, peer review committees, and Boards. He presented papers and keynoted many national and international meetings, as well as authoring articles for books and journals. His publication, "Guidelines for Trout Stream Management in Wisconsin" (1967) remains a classic reference. Ray's graduate students have never forgotten the standards of honesty and excellence that he set. He encouraged students to explore related fields and blend these disciplines in their work.

In the early 1990s, Ray wrote a series of articles on “Why Wild Fish Matter,” that highlighted the superiority of wild trout over genetically deficient domestic strains. These irrefutable articles significantly altered salmonid management.

Ray White has had an important impact on trout research and management for some 50 years and is well deserving of the WT-VIII. 2004 A. Starker Leopold Award.

R. Peter van Gytenbeek, Nonprofessional Level

The WT-VIII Nonprofessional Level Award has been made to a founder of this Symposium who has combined a successful business career with a lifetime of service to wild trout. He has worked tirelessly to preserve wild trout and the habitat that supports them by serving as a member of the Washington State Fish and Wildlife Commission and as a board member of many angling and conservation organizations.

R. Peter Van Gytenbeek is the only person to have served both as Executive Director of Trout Unlimited and as President of the Federation of Fly Fishers. He has recently accepted the position as President and Chief Executive Officer, Federation of Fly Fishers. Van is a graduate of Princeton University, was the publisher of Fly Fishing in Salt Waters Magazine, is the author of "Way of the Trout," and has coauthored two other books. He has served on a number of Symposium committees including the Awards and Program Committees. He was also on the WT-I Organizing Committee.

As part of a series of successful measures on behalf of wild trout, Van recently waged a very difficult campaign that resulted in a Washington State moratorium on killing wild steelhead. Van's accomplishments have been and remain in keeping with the best traditions established by A. Starker Leopold and is well deserving of this year's award.

The A. Starker Leopold Awards Committee is made up of former recipients including: Chairman Marty Seldon, Roger Barnhart. Robert Behnke, Gardner Grant, Robert L. Hunt, Ron Jones, Bud Lilly, Frank Richardson and Ernie Schwiebert. Added committee members at WT-VIII were the current year recipients. Otto Teller is a memorial member.

Acceptance Remarks for the A. Starker Leopold Professional Award

Ray J. White

Thank you very much for the award. I appreciate it deeply. In considering the situation, I'd like to credit fellow wild trouters—people it's been my good fortune to work and fish with, particularly Bob Hunt and Kurt Fausch, who are here today, also Cal Kaya at Montana State University, just down the road in Bozeman. There are those, as well, who, over the years, have invited me to visit projects and exchange ideas. Among those are Bob Wiley, Al Binns, and their associates in the Wyoming Department of Game and Fish—and certainly Bob Behnke of Colorado. I'd also like to thank groups that financially supported my students and me in research, like various arms of Trout Unlimited and Marty Seldon's former committee within Federated Fly Fishers.

The A. Starker Leopold honor means something special to me for various reasons. Some are personal, related to the spirit of wildness, wild fish, wild habitats, Starker Leopold, and indeed his family. There are also matters having to do with recent progress in public and professional appreciation of wild trout values—and advances in the science evident at this symposium.

Coincidences and Debts—Largely Personal

It is probably no mere *chance* coincidence that two recipients of the A. Starker Leopold Professional Award, Bob Hunt (at the last symposium) and myself, came from the same home town (at least Bob lived so close that he went to high school there), and that this was, moreover, the home town of Starker Leopold. Madison, Wisconsin, and its setting gave all three of us much in common that led to being associated with wild trout and the symposium. However, none of us knew each other when growing up in and around that town. Bob and I, as the saying goes, "went to different schools together," and Starker was almost a generation older than we were.

Much of what we had in common involved the diverse, inspiring natural and semi-natural surroundings of Madison. It involved fathers who took us trout fishing in the beautiful spring creeks—the many "Alder Forks"—north of town. It involved a university there that was strong in the biological sciences, and that influenced us even before we each attended it.

Pervading much of the Madison and the university that affected us—and extending into the rest of the state, for instance to a cousin who farmed our old family homestead and took up conservation practices in the 1940s—pervading all that was the influence of Starker's father, Aldo Leopold, founder of the field of wildlife management. Aldo Leopold's influences were indirect for Bob Hunt and me, nevertheless, very important. How lucky we were to grow up in that place and time!

I'll not go into semi-significant interactions of my relatives with Leopolds. I will mention, however, that the building in which I spent six years of junior and senior high school overlooked the Leopold home from right across the street. I was there in 1948, the year Aldo Leopold died. Soon after, his famous “Sand County Almanac” book (Leopold 1949) came out, and I became very aware of whose house that was. His widow kept the home, and I met her a couple of times.

More significantly, former graduate students of Aldo Leopold kindly saw to it that, as teenagers, Bob Hunt and I (unbeknownst to each other) attended the University of Wisconsin’s evening wildlife seminars. This gave us a good start on ecological matters.

As for Starker Leopold, I first saw him when he came from Berkeley now and then to give lectures at the UW Wildlife Department. One of the subjects was his study of Alaskan wildlife. I later came to appreciate his contributions at the Wild Trout Symposia.

Most significantly, Aldo Leopold’s former students led much important work done in the 1950s through 1980s by the State of Wisconsin’s fish and wildlife agency. When Bob Hunt and I got jobs with that outfit in the late 1950s, those people became our mentors. We benefited greatly.

A further Leopold debt: Yesterday, Frank Richardson showed in his historical talk some photos of Starker’s brother, Luna Leopold, the hydrologist and geomorphologist who took part in several Wild Trout symposia. His research toward understanding stream dynamics helped our field tremendously. In the bulletin on stream habitat management that Oscar Brynildson and I wrote (White and Brynildson 1967), and that Bob Hunt mentioned a few minutes ago, we drew from two landmark publications on fluvial geomorphology that Luna Leopold had recently co-authored (Leopold et al. 1964; Leopold and Langbein 1966); he kindly aided us by correspondence, as well.

Wild Trout Science and Management since the First Symposium

Wild trout—actually, salmonid—science and management have grown much since this symposium began bringing resource professionals and anglers together 30 years ago. Our special field has become strongly habitat-oriented, indeed ecology-oriented. By definition, it departs from the tired hatchery tradition of fishery work. The implications of that caused a bit of consternation among some public-agency officials at the first symposium in 1974, also at a few subsequent ones. However, crucial distinctions between wild and artificially bred fish now seem well enough recognized that no such tension arose at the present symposium.

Within our field’s expanded ecological emphasis, we see increasing appreciation that damaged streams, when relieved of human-generated harm, can do much to *self*-restore themselves as producers of wild fish. The same interactions of water, sediments, and vegetation that shaped the pristine stream forms to which fish adapted can often naturally regenerate favorable conditions. Sometimes much natural healing happens within only a year or two. Most streams probably do not need the artificial habitat structures we were advocating a few years ago.

Such knowledge comes from practical, case-history experience and from basic studies of salmonid stream ecology. The latter have burgeoned in the last 15 years, especially in the Pacific Northwest. Big things are happening there. I urge you all to learn about them. A good place to start is the new book, “Strategies for Restoring River Ecosystems” (Wissmar and Bisson 2003), mercifully compact but containing 11 insight-filled chapters by 40-some authors.

Essential knowledge comes also from population geneticists, material covered in Reisenbichler et al. (2003), a chapter of the just-mentioned book.

Much of what genetics teaches us can be summed up in a sentence: *The genetic make-up of a substantial wild, native population is the record of its ancestors' ecological success.* This resonates with meaning about why locally evolved wild fish populations matter: the gene pool of each contains the prescriptions for proper performance to persist and thrive in stream, lake, or sea. It also indicates an inevitable pitfall of artificial breeding: human intervention can neither duplicate nor improve on the prescriptions—only degrade them.

Note that it is *not* the genetic make-up of any individual in the population that embodies this vital record. A population's genetic composition (unless the number of its members has sunk unfavorably) is far more diverse than that of any one organism in it. Rich intra-population variation of complex traits, many being subtly behavioral, bear on reproduction, body growth, and survival, enabling the species to take fuller advantage of the place(s) in which it lives—and to persist in the face of occasional extreme natural swings in environmental conditions. We cannot know all behaviors involved in foraging, predator avoidance, redd-site selection, redd construction, and mate selection, to name a few requisite processes of any trout species. Therefore, we cannot maintain those behaviors in artificial breeding, much less improve upon them. The need is to preserve each local, native, wild fish population, that is, preserve the record, the diverse gene pool, which is the recipe for continued performance in proper habitats. It follows, of course, that the suitable local and regional habitats must be preserved (or restored), as well.

Thus, from such genetic and ecologic insight, we get the message: *Wild trout, yes! But native is necessary, too!* We've had that impressed on our field for the last 10 or 15 years. We're hearing it loud and clear in presentations here at Wild Trout VIII. It fits right in with Aldo Leopold's oft-cited advice to keep all the parts.

In that regard, consider a quote from the biography, "Aldo Leopold: His Life and Work," by Curt Meine (1988). The passage deals with the wide-ranging, March 1941 introductory lecture for his Wildlife Ecology course at the University of Wisconsin. In it, Leopold discussed advantages and limitations, indeed drawbacks of technology, and its far-reaching implications for "the land's carrying capacity," for society, for ethics, and even for trying to restore peace in the face of that era's expanding war. He pondered (Meine 1988, page 415) that:

Present world problems were a sign that humans had exceeded, or approached too rapidly, a certain upper limit of population density [if so, what now with world population that has tripled to 6.3 billion since 1941 and may surpass 9 billion by 2050?]. Continuing with the line of thought, Leopold traced its implications in regard to the course of science, the collapse of France, and the 'illogical' calls by Hitler and Mussolini to their countrymen to increase their populations.

Leopold returned to his basic point: the assumption that better living made for higher ethics. He saw 'much evidence against, as well as for, this universal thesis of technical culture. Perhaps ethics are too complex to follow automatically in the wake of newer Fords and shinier bathtubs.'

Leopold turned for hope to a further ecological principle. He cited the work of population geneticist Sewall Wright [also at the Madison campus] in support of the notion that the survival of a species depended, not on day-to-day ups and downs, but on its ability to withstand infrequent catastrophes. Species survive because certain individuals deviate from 'normal' and are able to survive the unpredictable, abnormal catastrophic event.

He went on to laud individualism as a possible “safety device” to ensure human survival.

Half the class must have wondered if they were in the right place. The other half were probably trying to make sense of their notes. All must have asked themselves what this had to do with bears, grouse, or rabbits.

So, we see that the basic insight on genetic and ecological connections existed over 60 years ago. The father of wildlife management surely perplexed his class that day with a vast context on politics, society, and ethics. The students may have inadequately noted—or even been unable to comprehend—Sewell Wright’s kernel about the importance of naturally evolved genetic diversity. But Wright’s and Leopold’s successors have driven it home to us. We can now much better understand what Starker Leopold’s father then meant—and what this means for reversing adverse human influences on wild populations.

The need is urgent to take action on this increasingly appreciated knowledge. As symposium speakers have emphasized, human population and technology (and political developments) are pumping up the pressure on wild trout resources. So all of us, especially those of us involved in management, let’s keep up the good work—and redouble efforts!

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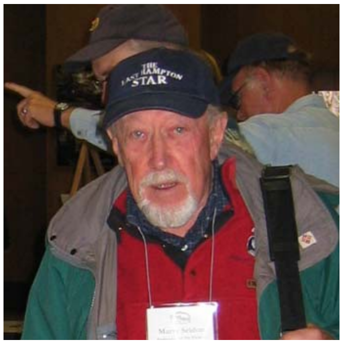
The History of the International Wild Trout Symposium



Marty Seldon

Federation of Fly Fishers, member of the Symposium Organizing Committee since 1979, Sunnyvale, California.

The first International Wild Trout Symposium was held September 25-26, 1974 at Mammoth Hot Springs Hotel in Yellowstone National Park. The event was cosponsored by Trout Unlimited and the Department of the Interior US Fish and Wildlife Service, based on the idea for the event that originated with Frank Richardson, TU Executive Director and past FFF President Pete Van Gytenbeek, John Peters of the EPA at a 1973 luncheon in Denver. The concept received the enthusiastic support of the Assistant Secretary of the Interior for Fish, Wildlife and Parks, and past FFF Senior Advisor, Nathaniel P. Reed. The sponsoring group was joined and the Symposium hosted by Yellowstone National Park's Jack Anderson. Willis King was also on the Organizing Committee. Over 300 anglers, writers, students, and professionals from every trout region in the United States and Canada met on common ground to talk about wild trout and establish a new tradition. There were panels covering Anadromous Species, Water Quality and Quantity, Habitat and Species, Regulations and Politics and a number of Special Sessions. Presenters included a number of familiar names such as Roger Barnhart, Gardner Grant, Ray White, Bob Wiley and our good friend A. Starker Leopold. Dick Vincent presented his well-known paper on the effects of stocking catchables on wild trout populations and Wilfred Carter head of the International Salmon Federation discussed Atlantic salmon management.

The initial consensus was to hold these Symposiums every five years and 1979 added the Federation of Fly Fishers as a cosponsor. John Townsley joined the Organizing Committee. Frank Richardson was Chairman.

Gardner Grant and Mike Owen, the respective FFF and TU Presidents, were Assistant Chairmen. Wild Trout-II, September 24-25, 1979, primarily focused on managing fish and anglers with fewer papers on managing water and watersheds. WT-II emphasized the importance of genetic adaptations in strains of trout and that locally adapted populations have great ecological advantages. The distinguished Lee Wulff and others discussed the importance of preserving the quality of the angling experience as differentiated from the full-creel mentality, and there were perplexing reports documenting declining fisheries. Rupe Andrews and Gerry Taylor compared the similar problems of the great Alaska and British Columbia fisheries. Ron Marcoux and John Varley brought us up to date on the results of the major Catch-and-Release fishery studies on the Madison River and in Yellowstone National Park. It was gratifying to see the very positive results. It all started in the Park with the major undertaking by Jack Anderson to save the cutthroat fishery in Yellowstone by closing angling at Fishing Bridge and establishing no-kill regulations. Starker Leopold asked that all administrators assign a high priority to the study of watershed relationships, such as grazing to trout populations. He said that better data to justify the conservation of riparian zones adjacent to streams is the real key to improved trout management.

The Symposium format remained the same. At WT-III, September 24-25, 1984, the US Department of Agriculture shared sponsorship. Roger Barnhart was Chairman again assisted by Gardner Grant and Mike Owen. Frank Richardson headed Programs along with Bob Barbee on Logistics and Bob Hamre Editorial. Keynote addresses by G. Ray Arnett Assistant Secretary of the Interior and John Crowell Assistant Secretary of Agriculture reminded us of the stark reality of a troubled resource, limited funding, competition among users, and the demanding effort we must all dedicate to the stewardship of our trout and salmon. Jackson Hole's Rev. Dan Abrams inspired us with a tale of the worth of a trout that extends far beyond nostalgia, sentimentalism and winter dreams. Ben Dysart, President of the National Wildlife Foundation, dramatically pointed to the larger picture and how trout hatchery management solutions have changed to encompass complete watershed management.

In August 1983, one year before WT-III the entire wildlife community lost a dear friend and a strong advocate. A. Starker Leopold an outstanding naturalist, teacher, author and effective public policy advisor, passed away at his home in Berkeley, California. It was a tragic loss to all. In recognition of his gentle eminence, the Sponsoring Committee established the A. Starker Leopold Award as a continuing memorial. Awards are given to a professional and a nonprofessional who over time have made significant contributions to the preservation of wild trout. The first awardees were Bob Behnke and Marty Seldon.

The mission of the National Wild Trout Symposium is to provide a forum for professional wild trout biologists and fishery conservationists to interact, to get to know each other in an informal setting, and to be exposed to the latest wild trout status, science, technology, and philosophy. These conferences equip participants to better preserve and restore this magnificent but declining resource. Although major national speakers and agency heads and administrators participate, this forum focuses on the needs of working level wild trout professionals and conservationists not on the requirements and problems of agency or organization management. The originators hoped that each symposium would be a building block upon which the succeeding symposium could take hold and provide, in turn, insights and research that future sessions could use to advantage.

Wild Trout IV was held September 18-19, 1989. Over the past 15 years, the Proceedings have grown from 102 pages to 233 pages as have the contents and scope of the presentations. The Environmental Protection Agency and the American Fisheries Society were added as cosponsors. Frank Richardson and Gardner Grant cochaired the symposium.

One of the major keynotes was by Nathaniel P. Reed who addressed the progress we made in the fifteen years that intervened since WT-I. He talked about our inability to explain ecosystem management to the public as was the case with the Yellowstone fires last year. He pointed out how Jack Anderson's restoration of the cutthroat trout with advice from Starker Leopold and Durward Allen made it possible to restore the Grizzly populations. Mr. Reed, as were many of us, said he was thrilled to see Luna Leopold with us this year and that we, as the caring vanguard, had fulfilled the constant need to better manage man's rapacious appetites in exceptional ways so that we can continue to save planet earth and the wild trout that seek to share it with us.

NWF's Benjamin Dysart joined us again as a Keynoter and although he approved of our scientific approaches to watershed, fishery, and habitat restoration, he pointed out that something more was needed to really be effective.

What is needed is to come up with h projects that have scenarios where everyone wins. Win-Win situations come about by working with right-minded developers, with the agencies, and with the anglers. The real challenge is to have desirable development that is done in a way that does not preclude public environmental quality values. When this takes place, everyone can win.

Bob Behnke was the WT-IV Symposium Summarizer. He looked at our progress including his observation that state and federal hatchery salmonid production had grown from a total of 169.4 million in 1958 of which 50.2 million were catchable trout, to 256.5 million salmonids in 1983 of which 78 million were catchable trout. The cost of each trout varied from $1.06 to $3.62 per fishing license sold creating an economic imbalance. Bob told us we could provide more angler days at lower cost by creating more wild trout opportunities and that more investigation is needed in this area. The 1989 A. Starker Leopold Award recipients were Frank Richardson and Otto H. Teller.

The organization of Wild Trout Symposiums normally includes Sunday Registration and a speakers and committee meeting and reception. Monday morning starts with a plenary session usually with top-level agency speakers like the Secretary of the Interior followed by two and a half days of sessions on all aspects of wild trout. There is an awards luncheon and a banquet. WT-IV has panels including the overall resource, fishery restoration, wildfire, drought and wild trout, fishery management, and fish economics, each with five to seven individual twenty minute presentations. The Symposium also includes poster papers and several exhibits. Well known author Richard Telleur reported on 25 years of no-kill regulations on New York's Beaverkill and Willowemoc rivers and an economic boom in Roscoe, New York that resulted from these special regulations. Similar results took place in Canada's five Atlantic seaboard provinces with no-kill Atlantic salmon regulations.

Wild Trout-V was held September 26-27, 1994 at the Symposium Headquarters at Mammoth Hot Springs Hotel in Yellowstone National Park. Roger Barnhart and Ron Jones were cochairman with the theme, "Wild Trout in the 21st Century." All three major arms of the Department of the Interior, The National Biological Service, the Fish and Wildlife Service and the National Park Service joined the ranks of Symposium cosponsors.

Jay Hair, National Wildlife Federation President and CEO presented the message that our society desperately needs to return to a sense of place. Exhilarating wild trout fishing is an endangered experience.

Secretary of the Interior Bruce Babbitt reflected on his experiences with issues of trout and ecosystems. He spoke about water quality and grazing impacts and how new ESA, Section 404 of the Clean Water Act and nonpoint pollution standards will protect our fisheries. He believed that the Forest Plan Management Act would help establish buffer zones in logging operations and that mining, urban expansion, water consumption, and road construction need similar attention and planning. "We can learn from the tragedies and mistakes of the past and begin to move toward an equilibrium upon the landscape."

There has been conflict going on for many years over these issues and it flares up in every generation. Our response has not been adequate to the Sagebrush Rebellion, The Great Fight or the Wise Use Movement. There are far too many signs of the environmental movement and the classic sportsmen conservation groups drifting apart. We are loosing too many sportsmen's groups and they are not pulling their weight as they should. Wild trout advocates need to bridge the gap between resource conservation and the sportsman tradition of

Teddy Roosevelt. Good science is wonderful but in the final analysis it's political clout. We need to find our constituencies make certain they understand that everyone's concerns are tied together to get quality ecosystems. That understanding has to be translated into political action. 1994 Recipients of the A. Starker Leopold Award were Ron Jones and Gardner Grant.

WT-V also looked at the negative aspects of the animal rights movement and introduced the use of DNA analysis to track the movement and interactions of 26 cutthroat trout populations. This work offered better approaches to defining genetic diversity and indicated that we cannot draw valid conclusions from only looking at single isolated populations. Other papers included a view of New England Atlantic salmon restoration where populations in 28 rivers have declined from 1.1 million returning adults to less than 4,000. Ray White discussed why wild trout matter, we looked at wild trout management in British Columbia, and at a number of restoration projects.

Robert Martin summarized WT-V by pointing out that the greater public will determine the future of wild trout in the next century. It was about time we stopped pedantic discourses on "when is a wild trout a wild trout." There should be no dispute that in an environmentally balanced world wild trout would always be preferred over hatchery trout. Hatcheries represented only the need for temporary mitigation. The clarion theme of WT-V was that those involved in wild trout must convince the greater public of their value if they are to survive. Fishery management agencies must represent and protect the interest of the unorganized groups. Managers and advocates must stop arguing among themselves and share their passion for wild trout with the public. The other improvement that was instituted was to increase the symposium frequency from 5-years to 3-years to be better able to keep up with the more rapidly changing resource.

In an effort to overcome one of the difficulties, of the limited capacity and accommodations at Mammoth Hot Springs, Wild Trout-VI was held at the excellent convention facilities of Montana State University, Bozeman, Montana. Pat Dwyer was Symposium Chairman. Attendance was limited

by the American Fisheries Society scheduling their conference on the West Coast the following week, but WT-VI presented one of the better technical sessions. The Symposium was organized into panels that included Public Awareness and Education, What's a Wild Trout Worth (economics), Wild Trout Family Trees (genetics), Trout in Trouble (diseases and threats) and Trout on the Rebound (restoration projects). Each panel consisted of 5-10 papers; each limited to a 20-minute presentation and 5 minutes of questions. Papers ran from Monday morning, all day Tuesday and half day on Wednesday. The 1997 recipients of the A. Starker Leopold Award were Roger Barnhart and Ernie Schwiebert.

Wild Trout-VI focused on the formation of user group and agency partnerships including ones for bull trout in Alberta, Canada, cutthroat trout in Colorado, and one with the University of Moscow to preserve Kamchatka Peninsula steelhead. It looked at improved management techniques, the latest developments in genetic research, and at the increasing public use of National Parks impacting all fish and wildlife. Examples of the value of wild trout included a $9 million annual economic contribution by anglers after the institution of barbless hook, Catch-and-Release fishing on the Beaverkill and Willowemoc watersheds in Upper New York State. New DNA analysis was used to confirm the discovery of new salmonid species/subspecies of New Mexico Gila trout, cutthroat trout in Colorado and Nevada as well as three different groups similar to cutthroat trout in Kamchatca. Work in this exciting field is just beginning. WT-VI looked at the serious problems being caused by Lake Trout in Yellowstone Lake and the spread of Whirling disease. Possible threats from Global Warming and examples of the loss of more cold water habitat and rainbow-cutthroat trout hybridization in Idaho, Montana, and Ontario Canada were also presented.

Examples of successful restoration projects were highlighted by well known River Keeper Ron Holloway who discussed how Great Britain's Itchen River wild brown trout fishery had been abused, destroyed and then restored over the past three centuries. Consideration of the management of the total watershed rather just attacking problems at specific sites was one of the main factors. Man has the knowledge to "put the natives back into wild trout.” What is needed is the will. Spencer Turner, WT-VI Summarizer concluded that professionals, guides and all the user groups have a lot in common including our love of wild trout and of the rich, cold, environs that support these wondrous creatures. We all need to continue to work together but we have come light years since Wild Trout-I and that the future of wild trout resources is quite optimistic.

A highlight at WT-VI was the legendary Ernie Schwiebert who extolled the poetry of wild trout he loved as a child. 'Everything about such wild trout is beautiful. The cold lakes and rivers that sustain them are beautiful. The methods of catching them are beautiful, the equipment we use is beautiful, and the flies we dress them with are beautiful. Fly fishing is both old and honorable. Its roots like in medieval chivalry itself, and we share a literature of sport more than five centuries old. It is filled with bright rivers tumbling swiftly toward the salty, the deft choreography of swifts and swallows working to a hatch of fly, and the quicksilver poetry of the trout themselves. And. In seeking their beauty, we may still discover that beauty itself is the most endangered thing of all."

Wild Trout-VII started the new millennium and brought us back to Yellowstone National Park, where these important meetings originated. Initial planning by the Organizing Committee for Wild Trout-VIII suggested a possible return to the 1904 Old Faithful Inn and Lodge and that it be held in 2004 to commemorate the 30th anniversary of these Symposiums. We hope you will join us in the land of the magnificent cutthroat around the geysers, the bison, the bugling elk, and the occasional bear and coyote. We need your contribution to meet our ever pressing obligation to preserving and enhance what Ernie Schwiebert sees as the beauty of wild trout.

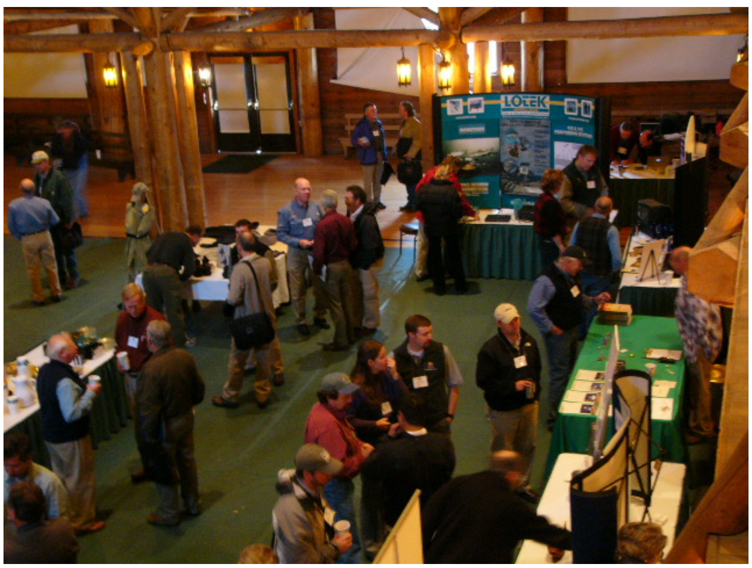
Wild Trout-VIII, the 30th anniversary of these forums, was held September 19th-22nd 2004 at Old Faithful Lodge, Yellowstone National Park, WY, USA. The Theme, "Ensuring the Future of Wild Trout: Working Together," was adopted. Perhaps it was the 210 preregistrants, that it had been four years since WT-VII, or that everything came together so very well, but there was a special positive spirit at WT-VIII. YNP Assistant Park Superintendent Robert Walker welcomed us and one of our symposium founders R. Peter Van Gytenbeek (founders include including Frank Richardson, John Peters with the approval and support of Assistant Secretary of the Interior Nathaniel P. Reed) reminisced about our beginnings in 1974 and how great it was to be together on our 30th anniversary. Ted Turner told us that we need to actively fight the battles to save humanity to save our fisheries, that we are all interdependent, and asked us all to step up to the plate to make things better.

Using a Liz Mamer PowerPoint presentation as a backdrop, our first luncheon speaker, another of our symposium founders, Frank Richardson reminisced about the 1972-1973 luncheons in Denver where the symposium concept was hatched, developed, and then carried it to Washington, D.C. for an enthusiastic endorsement.

Symposium Banquet entertainment by Greg Keller was met with standing ovations for this one-of-a-kind fly fishing MSU English professor turned completely innovate western folk singer. His fish and political songs had us in the aisles.

There were a series of really significant presentations and poster papers and a very good cross section of professionals and trout conservationists in attendance. Presentations from Australia, Canada, and England heightened our international concerns and we want to expand WT-VIII's excellent participation by the Montana State University Students Association to as many other areas as possible. Ray J. White and R.P. Van Gytenbeek were the two A. Starker Leopold Award recipients at WT-VIII. A grant from Advanced Telemetry Systems, Inc. (www.atstrack.com) has now made it possible to strike a medal to formalize these prestigious awards.

The 100-year-old facilities at Old Faithful Lodge and the Inn gave us more than enough room. Old Faithful going off on its regular cycle could not have provided a better environment for us all to gather, meet old and new friends, and to enjoy the excellent state-of-the-art wild trout overviews these symposiums engender. Based on Wt-VIII, we all can't wait until September 2007 for Wild Trout-IX. Please plan to join us.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American Fisheries Society

The Role of Government in Building Civic Capacity at the Watershed Scale: A Case Study of the White River in Vermont

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ABSTRACT—Collaboration between conservation groups and government is recognized as a necessity at every scale of aquatic restoration and stewardship, from backyard riparian buffers to watershed-wide fish passage. However, community-based watershed groups are often missing from the collaborative equation. This may be a serious flaw as ultimately it is the community's relationship to its streams and rivers that must change in order for long-term stewardship to occur. Infusions of government resources have resulted in significant outputs and outcomes addressing non-point source pollution and trout habitat where community-based watershed organizations have high levels of civic capacity. Conversely, a lack of civic capacity infused into government-led watershed-scale efforts creates a barrier to lasting change. The importance of civic capacity, defined as the network of relationships among individuals and institutions, and the potential role of government in its development cannot be overstated. Presented here is a case study and chronology of civic capacity-building in the White River Watershed in central Vermont. The White River Partnership, a grass roots watershed group, came into existence in 1995. By 1999, the watershed was a U.S. EPA National Showcase Watershed and one of 16 Community-Based Watershed Restoration Projects nation-wide to receive generous funding from the USDA Forest Service. State and Federal financial and technical resources have been critical to the development of this strong non-profit watershed organization that now serves as the link between more than 20 organizations and 21 communities within the White River watershed. Resource management agencies and other grantors should consider the long-term benefits of investing in capacity building activities in addition to tangible restoration projects.

Introduction

The White River is Vermont's fourth largest watershed, draining an area of 710 square miles and encompassing all or part of 21 towns. The river flows southeast for 56 miles, with its headwaters in the Green Mountain National Forest at an elevation of 3,700 feet and enters the Connecticut River at an elevation of 330 feet. It is the longest un-dammed tributary of the Connecticut River. Land ownership is 84% private, 11% National Forest and 5% municipal and state land. Land use is 84% forested, 7% agriculture and only 5% developed. Figure 1 shows the White River watershed and its six sub-watersheds.

The White River is part of the Connecticut River Atlantic Salmon Restoration Program and a Special Focus Area of the Conte National Fish and Wildlife Refuge. The main stem and its tributaries support populations of native wild brook trout and naturalized brown and rainbow trout. The Vermont Fish and Wildlife Department augments the fishery in the main stem and some tributaries by stocking catchable-size brook and rainbow trout. Thirty-seven percent of the 125 sites monitored over the past 50 years had only brook trout and 19% had all three trout species.

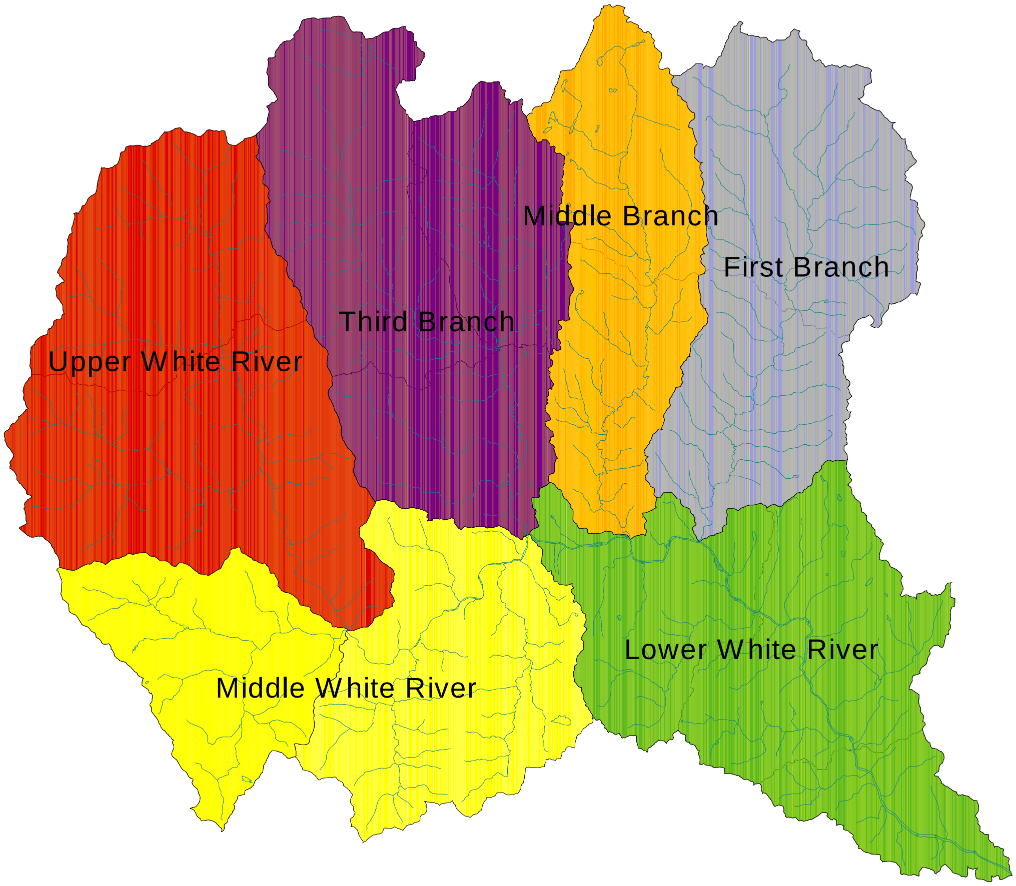

Figure 1. White River watershed with six sub-watersheds.

The White River watershed has tremendous human, cultural and natural resources, but faces many challenges on the journey to sustainable communities and natural resource stewardship. Large-scale in-stream gravel extraction was common on the main stem and tributaries until 1986. River morphologists believe the watershed is still experiencing instability due to decades-old gravel extraction. The straightening of stream channels and removal of riparian vegetation to facilitate transportation and agriculture had also had lasting watershed-wide impacts. Sedimentation from eroding banks, elevated water temperatures and the loss of riparian functions have reduced aquatic habitat quality for trout and salmon in many reaches of the watershed.

Presently the watershed is 84% forested, however, at the turn of the 20th century it was only 20% forested.

Collaborating on the Watershed Scale

Milestone #1: The ground work is laid for Forest Service to engage in community-based watershed collaborative.

The USDA Forest Service (Forest Service), and specifically the Green Mountain National Forest, is no stranger to working in partnership to accomplish management goals. Recreational, fishery and wildlife resources on national forests are important enough to both local and national conservation organizations to spend vast amounts of volunteer and financial resources to implement on-the-ground projects on public lands. What was new to the agency in the early 1990's was clear direction from Congress emphasizing an expanded role outside National Forest boundaries within the communities that are linked culturally, economically and environmentally to public lands (McAllister and Zimet 1994). McAllister and Zimet (1994) reported on 12 case studies across the country where the Forest Service had turned outward to work with forest-dependent communities. Although the case studies they presented focused on areas that were more dependent on national forest timber than the White River watershed, the groundwork had been laid for collaborating with local communities across political boundaries on the watershed-scale.

In the Forest Service's report on its 1993 national workshop on collaborative planning (Forest Service 1993), they recognized that most in the agency *"were accustomed to top-down planning, in which few decide for the many, and change comes from outside*". The report went on to describe collaborative planning as emerging from the community, honoring a full spectrum of values and assumes everyone is responsible for the community's success. *"There is no one leader and no one is excluded from the table."* To the Service's credit, it realized that with this newfound role and shift in thinking came the need for new skills not previously valued or nurtured in the organization. Fortunately, for the White River watershed, the skills required were well honed and highly accessible at the George D. Aiken Resource Conservation and Development Council (RC&D Council) and the Regional Planning Commission (RPC).

Milestone #2: A project-level partnership provides the vision for a watershed-scale collaborative.

In 1993, a geographically small but complex issue along the banks of the White River brought together private landowners, the Forest Service, Vermont Agency of Natural Resources (Vermont ANR), the RPC, town and state highway managers, and the local RC&D Council. The project involved fish migration, riverbank erosion, road damage and a small piece of National Forest sandwiched between private lands. Resolution clearly called for the participation of multiple agencies and landowners as well as creative financing. A seemingly over-sized group of would-be stakeholders mulled over the project in fog of jurisdictional uncertainty for some time before progress was made. In the end, three years later, the fish still could not navigate the barrier; the partners raised enough funding to study the cause of road failure but not fix it; and only one of the two private landowners found resources to stop their bank erosion. The project was hardly a glowing example of collaborative planning, partnerships and civic capacity. Yet, it was not a complete failure in that some goals were met and the seed of collaboration was planted.

Milestone #3: Adopting a community-based and locally led model—a shift from government led to government participant.

Under the leadership of the RC&D Council, the RPC, the Vermont ANR and the Forest Service recognized the potential for collaboration to address a growing number of river related issues. Local, state and federal government representatives and local and national conservation groups struggled for more than a year to define their roles and goals in a 710 square mile watershed that was 84% privately owned. A break through occurred in 1994 when staff from the Green Mountain National Forest, Vermont ANR and the RC&D Council took advantage of a Forest Service Collaborative Planning Workshop—a spin off from the 1993 National Workshop**.** The training event provided the critical thrust and momentum needed to kick off a watershed event. Using the collaborative planning approach, the initiative quickly transformed from an agency-led initiative to an agency-facilitated initiative being locally led by the people who lived, worked, recreated, and did business in the White River watershed. In affect, there was a paradigm shift where government took a seat at the table as one of the participants, joining the circle instead of being at the head of the table.

Birth of the White River Partnership

Milestone #4: Hiring a Watershed Coordinator to assure steady forward movement and continued enthusiasm.

In January 1995, an organizing body was expanded to include more local groups and community leaders with interests not only in the well being of the natural resources but also the quality of life in their communities. Extensive brainstorms and lengthy discussions by the fledgling group resulted in an aggressive plan to involve community members in a locally led initiative encompassing 21 towns within the watershed. It quickly became evident that a labor intensive and complex planning project was in the making. The RC&D Council and the RPC had the technical expertise to help guide the process but neither had the necessary human resources to see it through.. Practitioners and observes of community-based collaborative efforts generally agree that chances for success are increased when an individual can be charged with doggedly pursuing the organizing body's vision for planning and implementation (McAllister and Zimet 1993; Doppelt et al. 2002). The process is often messy and protracted, requiring more time and energy than a volunteer project coordinator can typically offer. In the summer of 1995, the RC&D Council received a rural development grant from the Forest Service and a partnership grant from the Silvio Conte National Fish & Wildlife Refuge to create a half-time Watershed Coordinator position.

Milestone #5: Residents of the watershed provide the framework for the White River Partnership's plan of action.

As the initiative gathered steam and participants planned a series of community forums, it took on the name White River Partnership (WRP) with the initial goal of forming a grass roots organization to actively promote the social, economic, and environmental health of the White River. The Partnership adopted two principles in its pursuit of a community-based collaborative: 1) The initiative must be developed by the residents of the White River watershed; and 2) the initiative must be developed collaboratively whereby all interested persons and parties may take part.

In October and November 1995, the Partnership conducted six public forums. Over 150 people from communities throughout the watershed came together to express their views on: what they wanted for the future; what issues and opportunities needed to be addressed; and what were the next steps to be taken by the citizens, communities, conservation groups, local governments, and resource management agencies to achieve their shared vision.

Organizing for Action

Milestone #6: Organizational structure creating community-based, locally led Stream Teams to identify and implement projects with technical and financial assistance from partners.

A prioritized list of issues and next steps was compiled from the six public forums. Of particular interest is the variation in prioritization by the different geographic regions of the watershed. While all the forums identified stream bank erosion and public awareness as priorities, only the communities at the lower end of the main stem identified pollution as a priority, and only the upper portion of the main stem made gravel removal a priority issue. Clearly, a one-size fits all approach on a regional or whole watershed scale would not suffice.

The diversity of community interests led the White River Partnership to look towards a decentralized organization model. A single centralized steering committee or board of directors could not adequately represent and serve the entire watershed. The ridge and valley topography of the watershed created obvious ecologically significant subwatershed boundaries. The geography has also influenced early settlement patterns, socially and economically linking communities within the subwatersheds. Hence, the watershed was well suited to creating local groups, called Stream Teams, to implement the partnerships mission in each of six subwatersheds under the guidance of a WRP Steering Committee. This model has served many watershed groups well throughout the country.

Building Local Civic Capacity

Milestone #7: The WRP established its first Stream Team to provide local leadership while government agencies and conservation groups form an inter-agency technical team.

In 1996, the WRP began building the capacity to implement the “Next Steps” identified by community members. Human, technical, and financial resources were needed to transform the energy and enthusiasm created by the forums into real action. Once again, under the leadership of the RC&D Council and continued seed money from the Forest Service, Conte Refuge and Trout Unlimited (TU) for the paid coordinator, the WRP received a two-year, $35,000 grant from VT Department of Environmental Conservation (VT DEC). The funding was to address non-point source pollution from stream bank erosion in the upper White River watershed. A state government partner had met the need for financial resources with remarkably few strings attached. The WRP initiated the development of a technical team made up of partners from state and federal agencies and TU. The Forest Service agreed to provide the staff time to coordinate the technical team’s involvement in the project. Again, partners met the need. The Forest Service, USDA Natural Resource Conservation Service, U.S. Fish & Wildlife Service, VT Fish & Wildlife Department, VT DEC and Trout Unlimited formed a Stream Restoration Technical Team to advise the WRP on fish and wildlife-friendly techniques to slow erosion on privately owned streambanks. The final step in the initial capacity building effort was to pull together local leaders, citizens and landowners in the upper portion of the watershed to help identify and prioritize project sites. The Upper River Stream Team was born and the network of individuals and institutions was formed. After two years, the project restored nearly a mile of stream bank and riparian habitat at six sites on the White River.

Milestone #8: Environmental Protection Agency's (EPA) National Showcase Watershed web site up and running and development of inter-agency training programs.

In 1998, as a direct result of the projects completed by the Upper River Stream Team and partners, the WRP was selected as one of 12 National Showcase Watersheds demonstrating the "principles, processes, and practices of stream corridor restoration." While the showcase designation did not come with additional resources, it did provide important recognition for the WRP and further increased capacity—people like to join a successful cause. By the time the U.S. Environmental Protection Agency's National Showcase Watershed web site was up and running: the Partnership had formed an additional Stream Team; and the Technical Team had embraced a natural channel design approach and began developing inter-agency training programs. In addition, the WRP established itself as a membership organization with well-articulated mission, vision, and guiding principles.

Milestone #9: Community-based Watershed Restoration Partnership grant from the Forest Service allows WRP to hire a full-time Watershed Coordinator and an Outreach and Education Coordinator.

In 1999, the stars aligned to bring the WRP a tremendous opportunity that few non-profit watershed groups experience—a large multi-year grant to fund both staff and stream corridor restoration projects. The early 1990s had brought focus to working on the watershed scale in communities highly dependent on National Forest timber. Now the focus had broadened with the realization that "solutions to watershed issues required working collectively across mixed ownerships within a watershed" (USDA Forest Service 2003). To this end, the Service selected 16 projects from a nation-wide request for proposals to receive five-year grants to develop Community-Based Watershed Restoration Partnerships. The partnership projects selected averaged only 46% national forest lands. The White River was one of those watersheds with only 11% national forest ownership. The grant was for approximately $1.4 million.

The infusion of financial resources immediately opened doors for the Partnership. Activities that are typically difficult to fund, such as full-time staff, collecting base-line data, river morphology assessments, and publications, came within reach. In addition, the grant included funds to implement stream restoration projects on private lands. Without the need to do almost continuous fund raising the organization focused on increasing partnerships, engaging communities and building and supporting the local Stream Teams.

Once grant funding was in place and a full-time coordinator was hired, the WRP took off. A comprehensive business plan, required by the Forest Service, helped the Partnership focus its efforts and develop a strategy to grow the organization into a self-supporting non-profit watershed group while it was actively pursuing balancing the cultural, economic and environmental health of the watershed.

Measuring Success in Terms of Capacity Building and Outputs

Following the community-based watershed restoration grant the WRP grew considerably in civic capacity and tangible outputs. As of 2004, the six Stream

Teams are in operation and the Partnership has contracted with the National Wildlife Federation to coordinate and manage restoration projects. In addition, a water quality internship program was started. Accomplishments that will benefit wild trout include:

- Approximately 5 miles of stream restoration
- 10 miles of riparian planting.

Between 2000 and 2003 the Partnership spent $1.8 million. Approximately 66% ($1.2 million) came from the Forest Service. The question will invariably be asked, "was this a good investment?" Using a modest estimate of $100,000/mile for natural channel design restoration and $12,000/mile for riparian reforestation, the agency could theoretically have accomplished 10.7 miles of habitat restoration for wild trout over that 4-year period on their own. However, it would likely have ended there in 2003.

Whereas government programs can often deliver expedient and cost efficient technical and financial services to riparian landowners, developing collaboration and consensus is complex and time consuming. The advantage is that the collaborative lives on after project money is gone. Following is a partial list of WRP activities and accomplishments that the typical grantor does not fund but were important capacity building factors funded all or in part by the Forest Service grant:

- Weekly water quality monitoring at 23 sites throughout the watershed
- Remote sensing of stream corridor conditions throughout the watershed
- 145 miles of stream assessment involving rapid geomorphic and habitat assessments
- Annual river cleanup events
- Approximately 800 volunteers planting trees
- Coordinated water quality monitoring protocol for schools/teachers in the watershed
- Development of watershed map focusing on cultural, economic and environmental assets
- Stream Teams established in each of the six sub-watersheds
- Over 420 individual landowners informed about state and federal buffer programs.
- Nine of 21 towns in the watershed made modest contributions of financial support
- Contributing membership reached 240 individuals and businesses
- Application of Vermont DEC Stream Corridor Management Framework
- Forestry working group assisted by university of Vermont to develop forestry framework.

Engaging communities to allow leadership and capacity to develop requires a different way of thinking about accomplishments and timeframes. Measuring the success and long-term benefits of community engagement does not fall neatly into the typical natural resource agency's metrics of cost/mile, miles/year, and fish/mile. In an extensive evaluation of the successes and failures of the Forest Service's community-based watershed restoration partnerships, researchers from Portland State University recognized that the strongest partnerships were found in areas where civic capacity was high (Doppelt et al. 2002). The researchers described civic capacity as having three components: social capital (networks of individuals and institutions); community competence (knowledge, skills and abilities within the community); and civic enterprise (history of collective action). In their report, several observations specific to the White River Partnership clearly point to a strengthening of civic capacity:

- Outreach and education projects are changing the publics view of the river
- The WRP feels empowered to take responsibility for projects
- The WRP provides a forum for all agencies to come together and develop better communications
- Public knowledge about the WRP is starting to snowball due to community outreach and getting projects on the ground
- The WRP has gained broad support from several groups around the State including the agricultural community, local towns and counties and federal agencies.

The WRP business plan (White River partnership 2003) contains an excellent section on outcomes and measures related to stream restoration goals. The plan also lists several measures associated with education, outreach, and capacity building. Their measures include: (1) Dollars raised annually from membership; (2) Grant writing success; (3) Number of schools with watershed curriculum; (4) Number of towns providing funding, materials, etc.; and (5) Number of active sub-watershed groups.

These measures track significant accomplishments gained through painstaking communications and relationship building. Of particular interest in the Forest Service community-based grants is grantor expectations. Most restoration grants are tied to tangible outputs and outcomes. While on-the-ground results were extremely important to the success of the community-based partnerships, softer targets, such as capacity building, were valued as well.

Conclusions

The White River Partnership is a success because of the commitment and hard work contributed by the citizens of the watershed. More than 20 partner organizations also make important contributions. However, were it not for local citizens, the initiative pondered by the government agencies back in 1993 would have been a very different creature. The turning point of the initiative came with the shift from government-led to a locally led, independent organization. Government agencies can take a seat at the table as just another partner with resources to bear. To do so takes a different mindset and skill set than a top down planning approach where a few decide for the many.

When a government grants program measures success in acres and miles of treatments over the life of a one or two year grant the return on investment is rapid. This is an effective model when civic capacity is high. Public-private partnerships can flourish because communities have the networks, skills and history to work collaboratively. Where it is low, government agencies have a role to play in building capacity in addition to putting projects on the ground. The Forest Service community-based partnership grants were a much more risky investment with long-term paybacks anticipated from: building networks; developing knowledge, skills and abilities in communities; and creating a history of collective action. The wheels are in motion and what remain to be seen are the accomplishments in 2005 and beyond.

The real fruit of the White River partnership's labor will be the slow change in communities' relationships to their rivers and streams. An awareness and understanding of how 225 years of land use has changed the character of their watershed will eventually inform community decisions. Knowledge of how rivers function to provide habitat will begin to inform how communities interact with their river channels, riparian forests, and flood planes. These changes will likely play a greater role in the future of wild trout habitat in the White River than all the government programs combined.

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Trout Unlimited and the Pennsylvania Mennonite Community—A Partnership to Enhance a Stream

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ABSTRACT—1995 and 2001 assessment reports of the Sacony Creek by the Pennsylvania Fish and Boat Commission (PFBC) (section 2, stations 0201 and 0202) were compared to the Berks County Conservation District's June 2004 study of the same stations. The PFBC conducted their 2001 assessment up to and including Station 0201 to examine potential effects of a newly installed sewer discharge. Compared to the 1995 study, we found that there was an increase in sensitive macroinvertebrate taxa at station 0202 and a decrease in the amount of coldwater fish species. There was an increase in sensitive macroinvertebrate taxa at station 0201 compared to the 2001 PFBC study and the same amount of pollution intolerant taxa compared to the 1995 PFBC study. Comparing both PFBC 1995 and 2001 studies, there was a decrease in the amount of coldwater fish species at station 0201. Stream restoration work implemented by the Tulpehocken Chapter of Trout Unlimited along this section of the Sacony Creek in conjunction with the cooperation of landowners has helped protect the stream. This has led to the development of moderate aquatic ecological improvements and valuable education and outreach to participating landowners.

Introduction

Few studies address the long-term effects of stream restoration on aquatic ecosystems in a specific watershed. Here, the biological water quality improvements of stream restoration projects implemented by the Tulpehocken Chapter of Trout Unlimited (TCTU) on the Sacony Creek from June 1999 to June 2004 are examined. Additionally, stream enhancements through unique community partnerships are analyzed. The Sacony Creek originates in the forested mountains of the Reading Prong, a few miles south of Kutztown, PA. At this point, the stream is classified as Exceptional Value (EV) (Chapter 93 - 2003), a designation given to streams in Pennsylvania with optimum water quality. Additionally, the headwaters are awarded a Class A Wild Brown Trout Stream designation. After running off the mountain, the creek meanders through the small town of Bowers and a large agriculture community that is populated by Mennonites. Land use in this community changes from a forested canopy-covered ecosystem to a dense agricultural ecosystem. Here, the creek loses its Wild Trout designation and drops from an EV stream to a Cold Water Fishery (CWF) (Chapter 93—2003).

In the 1995 study, Mike Kaufmann, PFBC, specifically recommended, "If an interested sportsmen's group can be found, habitat improvement projects, including streambank fencing, tree planting, and some in-stream work should be implemented in Section 02 in an effort to extend wild trout population downstream and provide cooler water temperatures for stocked trout." Because of the creek's exceptional headwater classification and the potential of habitat improvement downstream of this area, the TCTU became interested in restoring the stream, improving trout habitat and encouraging landowner participation in the lower classified sections. By using creative techniques such as speaking Pennsylvania German to establish a rapport with the Mennonite landowners and partnering with the summer youth of the Berks County Juvenile Probation Office, TCTU successfully implemented numerous best management practices in this CWF region. With the recommendations from the PFBC, the Tulpehocken Chapter of Trout Unlimited started to gather partners to plan their restoration efforts in the Sacony Creek.

In 1999, the Tulpehocken Chapter of Trout Unlimited commenced the implementation of eight stream restoration projects along a 2.3-mile stretch of the Sacony Creek. During a five-year span, the group worked with seven Mennonite farmer landowners and one municipality. TCTU started at Bowers Park and worked their way downstream towards Kutztown. They installed a total of 13,681 feet of animal exclusionary fencing, ten cattle crossings for pasture access and water sources using 120 tons of 2A modified stone, and planted 4,050 native shrubs and 325 native trees. 1,577 tons of R-4 rock, 25,790 square feet of coir matting, 8,750 wire staples, 325 pounds of grass seed and 950 feet of biologs were used to stabilize the stream banks. To enhance trout habitat, 30 log deflectors were installed in the streambed.

TCTU secured funds from multiple sources to execute these best management practices: William Penn Foundation, $23,490, administered by the Berks County Conservancy, the Pennsylvania Department of Environmental Protection's Growing Greener Grant Program, $58,374.26, local Mennonite farmers, $7,122 and in-kind services valued at $15,000 were provided by TCTU and their summer youth program. TCTU works with the Berks County Juvenile Probation Office, which allows troubled youth to volunteer their time to these stream restoration projects. The summer youth program volunteered 1,912 total hours during the entire project.

Methods

The PFBC's 1995 and 2001 assessments of the Sacony Creek were compared to our June 2004 study of the same stations. Sampling in the 1995 and 2001 assessments also occurred in June. The goal was to take data from the 2004 study and correlate improvements with the projects completed by TCTU.

Two different types of organisms were assessed in the June 2004 study, benthic macroinvertebrates and fish. Macroinvertebrate sampling was conducted Monday, June 14, 2004 using methodologies modified from the U.S. Environmental Protection Agency's Rapid Bioassessment Protocols, or RBP (USEPA, 1989), and the Volunteer Stream Monitoring Methods Manual (USEPA, 1997). Delaware Riverkeeper Network and Berks County Conservation District staff used a Surber sampler (500 micron mesh) and a D-frame net (500 micron mesh) to sample riffle areas as well as Course Particulate Organic Material, or CPOM (e.g. submerged logs, submerged aquatic vegetation, leaf packs). Riffle and CPOM habitats were selected for sampling because both are recognized as productive habitats for macroinvertebrates and typically contain a high diversity of benthic organisms.

The macroinvertebrates collected at each site were transferred from the Surber and D-frame net into one container. The sample was "picked" and individual organisms were sorted into separate containers. All macroinvertebrates collected were identified, most to order level, with a few aquatic insects identified to family level. This identification was completed in the field based on previous training, simple pictures and identification keys. All macroinvertebrates collected were counted streamside and returned unharmed to the stream. A standardized datasheet was used to record results.

Fish species were collected on Friday, June 18, 2004 using a Smith-Root, Inc. Model #12-B POW Electrofisher 400-600 Watts on a Cathode/Anode system. Data was collected using the U.S Environmental Protection Agency's RBP (USEPA, 1989). The sites selected were approximately 300 meters in length and correlated with the PFBC stations 0202 and 0201.

Stunned organisms were captured using dip nets and were temporarily held in buckets. The identification was completed in the field based on previous training and simple identification keys. All fish species were measured using a metric wooden measuring board, counted and recorded streamside, and returned to the creek. Because some trout were captured at stressful stream conditions (e.g. warm water temperatures), we observed these organisms in the net, estimated and recorded their measurement and released them immediately. A Fish Sampling Field Data Sheet from the EPA Rapid Bioassessment Protocol was used to record data.

Site 0202, which correlates with the PFBC Station 0202 assessment in 1995, was located at a farm southeast of Kutztown (Figure 1). The riffles selected for macroinvertebrate sampling were located downstream from a fenced cattle crossing. The dominant substrate in the riffle areas was cobble with gravel as the subdominant substrate. Riffle areas demonstrated moderate consolidation. Limited algal growth was observed on some rocks in the center of the stream. Fish sampling began at the downstream corner of the property adjacent to a fenced-off horse pasture and ended at the cattle crossing. The riparian buffer was well established with multiple overhanging trees and shrubs; we observed minimal bank erosion. It was difficult to stand up straight while conducting electrofishing in the streambed, due to a low hanging canopy. Adjacent to the sampling site, approximately 75% of the stream was shaded by riparian buffer habitat. Approximate buffer width on both sides of the stream was 15 feet. The land used on either side of the stream was utilized as open pasture. Habitat types at this location were about 10% riffles, 40% pools and 50% runs.

Site 0201, which correlates with the PFBC Station 0201 assessed in 1995 and 2001, was located at a farm northwest of Bowers (Figure 1). The riffles selected for sampling were located downstream from a farm lane bridge. The dominant substrate in the riffle areas was cobble with gravel as the subdominant substrate. Riffle areas demonstrated moderate consolidation. Some algal growth was observed on some rocks in the center of the stream. Fish sampling began approximately 30 meters upstream of the farm lane bridge and ended on the up-stream side of the railroad tracks at Bowers Park. Land use adjacent to the stream includes, riparian buffers, row crops and a fenced off pasture. The riparian buffer width was approximately 15 feet on both left and right banks. Approximately 70% of the stream was shaded due to a dense riparian buffer. Though the water appeared low in turbidity, a slight sewage odor was present while walking in the streambed. Habitat types at this location were about 30% riffles, 31% pools, 35% runs and 4% snags.

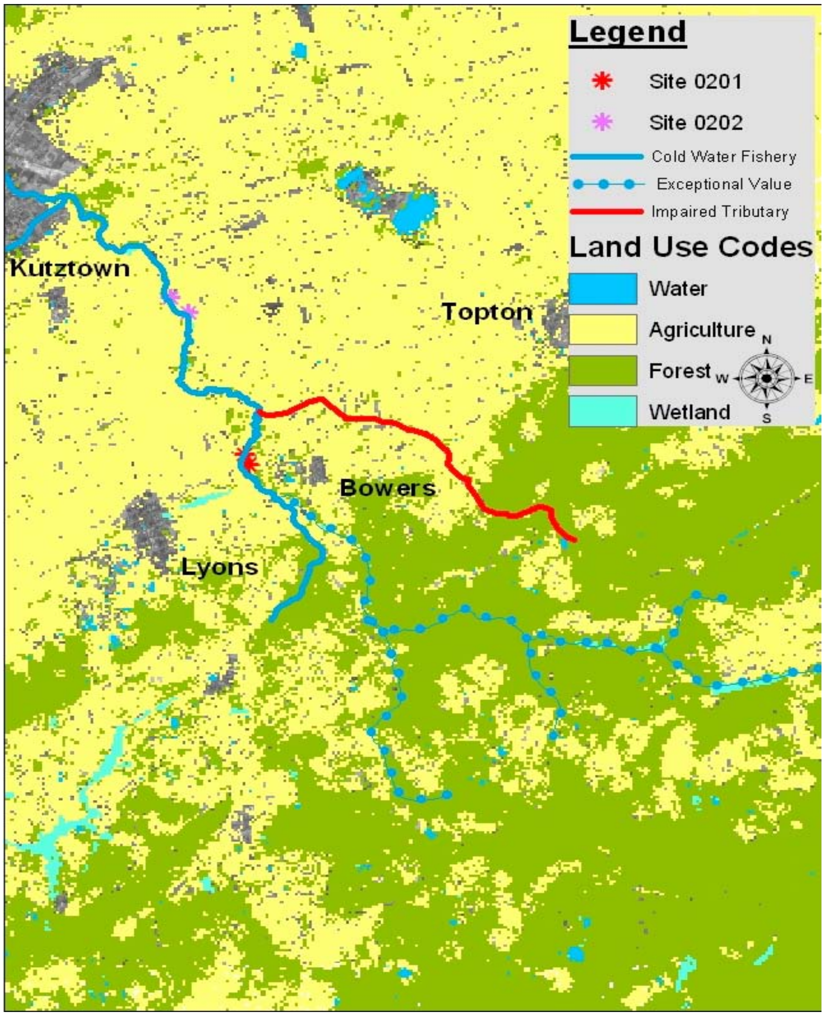

Figure 1. Land use surrounding the two study locations along the Sacony Creek and stream classification changes in the watershed.

Results

The Sacony Creek macroinvertebrate sampling data were analyzed using metrics recommended by Virginia Save Our Streams (VA SOS), the USEPA, and the Pennsylvania Department of Environmental Protection (PADEP):

- VA SOS examines a number of individual metrics (mayflies+stoneflies+caddisflies, common net-spinners, lunged snails, beetles, percent tolerant, and percent non-insects) then calculates a water quality score using a multimetric index. The VA SOS multimetric index identifies a numerical threshold that distinguishes between acceptable (7-12) and unacceptable ecological condition (0-6).
- The USEPA assigns tolerances (sensitive, somewhat sensitive, and tolerant) to taxa as well as codes based on the abundance of individual species present (Rare equals 1-9 organisms; Common equals 10-99 organisms; Dominant equals 100 plus organisms). Index values are calculated for each group. The total of all index values equals the water quality score (Poor = <20; Fair = 20-40; Good = >40).

- PADEP's Watershed Snapshot incorporates both a presence/absence rating and pollution tolerances. Taxa are assigned tolerances (S,F,T) and then a score is calculated for each group based on the number of taxa present. The site ranking is based upon the total of all group values or the number of sensitive taxa present (Poor = no S taxa or <11 points; Fair = 1 S taxa or 11-16 points; Good = 2 or 3 S taxa or 17-21 points; Very Good = 4 S taxa or 22-26; points; Excellent = 5+ S taxa or a score <27+).
- The PFBC rated their data according to present or abundant, where X = Present and * = Abundant.

Using the VA SOS system, Stations 0202 and 0201 both received ratings of Acceptable Ecological Condition. The same data used with USEPA tolerance criteria resulted in scores considered "Good". With the PA DEP Watershed Snapshot criteria the same data resulted in "Excellent" rankings for both sites. Each site exhibited a diversity of organisms. Sixteen (16) taxa were found at Site 1 including organisms from all three tolerance groupings: Group I, Sensitive, Group II, Somewhat Sensitive and Group III, Tolerant. Nineteen (19) taxa were found at Site 2, again including organisms from all three tolerance groupings (Table 1).

Table 1. Macroinvertibrate Composition

Aquatic organisms (Family/Order/Class)		2004 Station 0202	1995 Station 0202	2004 Station 0201	2001 Station 0201	1995 Station 0201
Group 1: sensitive to pollution and will quickly disappear if water quality is degraded	Water penny larvae, *Psephenidae*	2	*	27	X	X
	Mayfly nymphs, *Ephemeroptera*	21	X	74	X	X
	Stonefly nymphs, *Plecoptera*		X	9	X	X
	Non-netspinning caddisfly, *Trichoptera*	3	X	11	X	X
	Fingernet caddisfly larvae, *Philopotamidae*	2	X	4	X	X
	Free-living caddisfly larvae, *Rhyacophilidae*			2	X	X
Group 2: tolerate moderate amounts of pollution	Other beetle larvae, *Coleoptera*	34		3		
	Riffle beetle adult, *Coleoptera*	98	*	11		X
	Other beetle adult, *Coleoptera*	1				
	Cranefly larvae, *Tipulidae*	19	X	1		X
	Damselfly larvae, *Odonata*	2		2		
	Dragonfly larvae, *Odonata*			1	x	
	Scuds, *Amphipoda*	4	x	3		
	Aquatic sowbugs, *Isopoda*					
	Net-spinning caddisfly larvae, *Hyropsychidae*	40	*	81	X	*
	Water Mites, *Acariformes*	1		1		
Group 3: pollution tolerant	Aquatic worms, *Oligocheta*	6		7	X	X
	Blackfly larvae, *Simuliidae*	100^+	X	2		
	Leeches, *Hirudinea*	1			X	
	Midge larvae, *Chironimidae*	12	X	14	X	X
	Water striders, *Hemiptera*			5	X	
Total Individuals		**346**		**309**		

The Sacony Creek fish sampling data was analyzed using the Tolerance Designation metric (relevant to non-specific stressors) recommended by USEPA RBP (Appendix C), where I = Intolerant; M = Intermediate; T = Tolerant to pollution. Each organism was classified according to the above-mentioned levels.

River Chub are not commonly found in small headwater streams so Group 1 was recorded, but will not count in the overall results. Our collection was strictly based on the number of species captured. The PFBC recorded their data based on a subjective abundance index where: A = Abundant (> 100); C = Common (26-100); P = Present (3-25); R= Rare (< 3). Only the species captured by the PFBC and the Conservation District are charted. According to our data, there were 26 more Group 2 (Intolerant/Intermediate) fish species at station 0201 then at 0202 (Table 2).

Inaccuracies regarding macroinvertebrate collection were minimized because the technicians were more experienced in collecting macroinvertebrates and that these organisms are easier to capture than fish. Due to the technical field experience of the PFBC more fish species were captured at the 1995 and 2001 sites than in our 2004 sites. We felt we had a 60% capture rate when detaining the fish, compared to a much larger capture rate from the PFBC.

The fish that were captured and identified were identified to the best of our ability. Although we determined that all of the trout captured were wild, there are stocked trout in the creek. It is important to mention this to maintain quality assurance/quality control measures in this data.

Table 2. Composition of Fish Species

Fish Organisms (common name/genus/species)		2004 Station 0202	1995 Station 0202	2004 Station 0201	2001 Station 0201	1995 Station 0201
Group 1: **I** = Intolerant to pollution and will quickly disappear if water quality is degraded	*River Chub, *Nocomis micropogon*	2		1		
Group 2: **I, M—**Intolerant and Intermediate; sensitive to tolerant to moderate amounts of pollution	Brown Trout, *Salmo trutta*	3	P	10	C	C
	Northern Hogsucker, *Hypentelium nigricans*	6		11		
	Rock Bass, *Ambloplites rupestris*	5	P	5	P	
	Longnose Dace, Rhinichthys cataractae			14	C	P
Group 3: **M** = Intermediate—tolerate moderate amounts of pollution	Redbeast Sunfish, *Lepomis auritus*	11	P	4	R	
	Common Shiner, *Luxilus cornutus*	9	P	2	C	A
	Tessellated Darter, *Etheostoma olmestedi*	8	P	7	P	P
Group 4: **M, T** = Intermediate and Tolerant— tolerate more then moderate amounts of pollution	Banded Killifish, *fundulus, diaphanus*	2	A			
Group 5: **T** = Tolerant—pollution tolerant	Blacknose Dace, *Rhinichthys atratulus*		P	4	A	A
	Creek Chub, *Semotilus atromaculatus*	3	C		P	C
Total organisms		**49**		**58**		

** species is very uncommon in this ecosystem, could have been mistaken for a creek chub or a cutlips minnow*

Discussion

The purpose of the June 2004 study was to examine the downstream migration of cold-water aquatic organisms, compare the three studies and see if the affects could be attributed to TCTU restoration efforts. Based on the results from the 2004 study, it was determined that the stream restoration work implemented by the TCTU has led to moderately positive ecological improvements and valuable education and outreach to participating landowners. In five years, noticeable physical changes have occurred to the riparian buffer and habitat structures in the stream (Figures 2 - 4).

Though stations 0201 and 0202 have thick riparian buffers, it may be too early to see the effects of riparian buffer plantings on macroinvertebrates and fish along the entire 2.3 mile stretch. Once the newly planted trees establish a thick canopy cover, they should decrease stream temperature, enabling the stream to host more coldwater fish species.

According to the Pennsylvania's 2003 303(d) list of impaired streams, the small tributary that flows into the Sacony Creek downstream of Site 0201 and upstream of Site 0202 (Figure 1), is listed as impaired due to habitat and sediment. This tributary has not been rehabilitated by TCTU, and suffers from a degraded riparian buffer. The tributary is influenced by decreasing habitat and increasing thermal pollution, potentially affecting Station 0202 and other downstream sections of the Sacony Creek.

The eight projects took place along a transitional topographic point. The upper reaches of the project area are in medium gradient slopes, flowing off large hills and mountains. The downstream reaches are at lower gradients, which interrupt the stream's pool-riffle-run sequence. This sequence of pools, riffles and runs provides a heterogeneous physical environment that is utilized by many different types of organisms. Pools, riffles and runs provide refuge from stream velocity and extreme temperatures, spawning sites for cold-water fish, and habitat sites for benthic invertebrates and

Figure 2. Severely eroded stream banks at a location in between stations 0201 and 0202. Notice pine trees in background for reference.

Figure 3. This after picture shows streambank fencing excluding cattle from the stream, stabilized stream banks and improved in-stream habitat. This shot was taken immediately after the restoration.

Figure 4. Shot of the same site taken 2 years after restoration. Notice lush riparian buffer and stabilized stream banks.

plants (Gore and Shields 1995). The complexity of pool-riffle-run sequences offers a wide variety of habitat types necessary to support a diverse lotic community. Site 0201 (the higher gradient site) supported more coldwater fish and more pollution intolerant macroinvertebrate taxa than Site 0202 (the lower gradient site) because it has a more consistent pool-riffle-run regime.

Through their restoration efforts, TCTU formed numerous partnerships to accomplish their goal of improving the Sacony Creek. These partnerships were the driving force behind the stream improvement projects. Partnerships are crucial to providing effective watershed management schemes. Through a partnership, different people and organizations work together to address common interests and concerns (Conservation Technology Information Center, 2004). Through landowner cooperation and environmental responsibility projects of this nature continue to be possible.

Although reduction of non-point source pollution and downstream migration of coldwater fish may be difficult to quantify, it can be concluded that the best management practice implementation efforts conducted by TCTU and their partners have had a positive impact on the water quality in the Sacony Creek Watershed.

Acknowledgements

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Elwha River Dam Removal—A Public/Private Partnership in Ecosystem Restoration

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ABSTRACT—The Elwha River Ecosystem and Fisheries Restoration Act of 1992 authorized the Secretary of the Interior to acquire and remove the Elwha and Glines Canyon Dams in Washington State to "fully restore the Elwha River ecosystem and native anadromous fisheries." Funding for the restoration project is by annual appropriations, the initiation of which was stimulated by the efforts of non-profit organizations and members of the local community. Acquisition of the dams was accomplished in February 2000 with their removal scheduled for 2007. Restoration of the ecosystem will result in anadromous fisheries run sizes increasing from about 3-5,000 fish annually to over 390,000 fish in odd years (when pink salmon return). Resident rainbow trout and bull trout and searun cutthroat trout will benefit from the influx of salmon eggs, juvenile salmon, and adult carcasses, as well as habitat recovery. Over 70 miles of mainstem and tributary habitat as well as nearshore marine areas will be restored. The public will be able to assist in revegetation and fish restoration efforts.

Introduction

The Elwha River historically supported spring- and summer/fall-run chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), pink salmon, (*O. gorbuscha*), chum salmon (*O. keta*), sockeye salmon (*O. nerka*), winter- and summer-run steelhead trout (*O. mykiss*), sea run cutthroat trout (*O. clarki*), bull trout (*Salvelinus malma*), and resident rainbow trout (O. mykiss). Estimates of the historic production of salmon and steelhead suggest that about 392,000 were produced from the Elwha River, Washington system in odd years when pink salmon returned from the sea (ONP 1996). These runs would have contributed about 820,000 pounds of carcass biomass to the Elwha River ecosystem during those return years (ONP 1995).

Construction of two hydroelectric dams on the Elwha River in the early 1900s drastically reduced salmon and steelhead runs by eliminating access to over 70 miles of mainstem and tributary habitat (Figure 1). In addition to the immediate cessation of migration to about 93% of the once available habitat, the reservoirs trapped gravels which eliminated the replacement of spawning gravels eroded downstream of the dams, blocked the transport of large woody debris downstream and nutrients both upstream and downstream, and inundated about 5.3 miles of important low gradient river habitat. Operation of the projects caused the stranding of both juvenile and adult fish in the 1930s and 1940s, although operation approximating run-of-river largely eliminated the extreme unnatural river fluctuations downstream. Water temperatures downstream of the dams are increased about 4 degrees Celsius during the summer low flow period because of the absorption of solar radiation within the reservoirs. This temperature increase contributed to the pre-spawning mortality of about two-thirds of the 1992 chinook salmon return (Wunderlich et al. 1994).

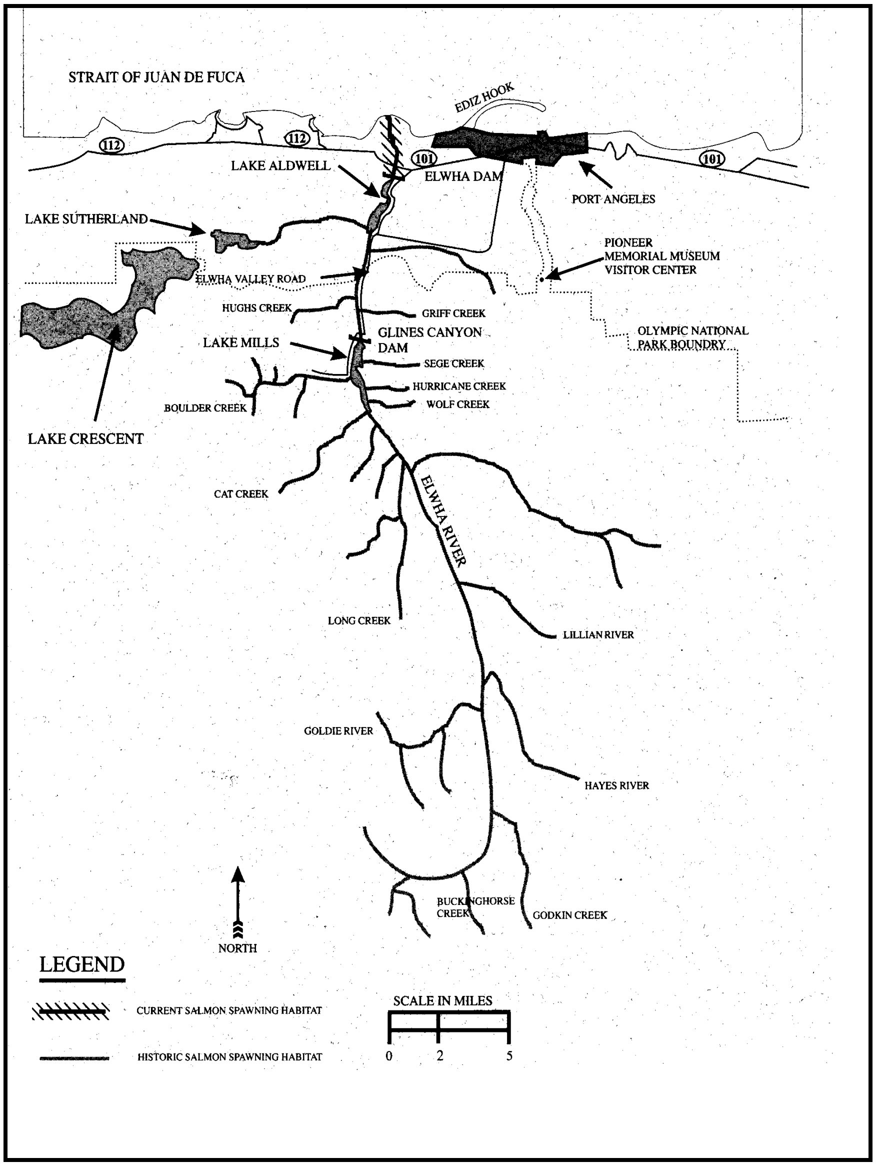

Figure 1. Location of the Elwha River, Elwha Dam, Glines Canyon Dam, and existing accessible area to anadromous fish (from ONP 1994).

The previous owner of the dams filed a first time license application for Elwha Dam with the Federal Power Commission (FPC) in 1968. Glines Canyon Dam had been licensed by the FPC in 1925 for a period of 50 years, so the owner filed a relicense application in 1973 (see www.nps.gov/olym/elwha/home.htm). These applications were consolidated in the Federal Energy Regulatory Commission's (FERC, previously the FPC) licensing process for these two projects.

In the early 1980's, the Lower Elwha Klallam Tribe (Tribe) and a coalition of four environmental groups submitted filings to FERC calling for the removal of both dams as mitigation for the adverse effect of the dams up to that point. FERC actually considered dam removal in its environmental impact statement for the licensing process, but of course also evaluated retention of the dams with the inclusion of fish passage facilities. It quickly became obvious that FERC's process was going to be mired in litigation for years to come.

Congressional representatives offered to draft legislation that could resolve existing and pending litigation over these dams. Their efforts resulted in a negotiated settlement among the parties to the FERC proceeding that became the Elwha River Ecosystem and Fisheries Restoration Act of 1992 (Public Law 102-495). This Act authorized the Secretary of the Interior to acquire and remove both dams to fully restore the Elwha River ecosystem and native anadromous fisheries.

However, this law might never have occurred were it not for the efforts of environmental groups and some Port Angeles residents. In particular, 13 individuals formed what they called the Elwha Citizens' Advisory Committee. This group was composed of people that opposed dam removal, supported dam removal, or were not strongly swayed one way or the other. They considered the pros and cons of dam removal, listened to presentations by groups and agencies in opposition and those in favor and ultimately concluded that dam removal was the best alternative for Port Angeles and Clallam County. This effort eliminated the opposition to dam removal by a U.S. Senator from Washington that opposed dam removal because it was not a "community based plan". Federal appropriations in support of project acquisition and removal also benefited from the continual support of citizens, environmental groups, and the Tribe. Federal acquisition of the two dams occurred on February 29, 2000.

Dam Removal

The Elwha Hydroelectric Project was constructed at RM 4.9 from 1910 to 1912. It has a central concrete gravity-type section that is 105 feet in height with a span of 450 feet at its crest and two sets of spillways. The original powerhouse contains two horizontal Francis turbines. A second powerhouse was constructed about ten years later and it contains two vertical Francis turbines (Figure 2). The total installed capacity of this project is 14.8 MW (FERC 1993). Lake Aldwell, the reservoir created by Elwha Dam, has a storage capacity of about 8,100 acre-feet with a maximum drawdown capacity of about seven feet—there is no low-level water outlet at Elwha Dam.

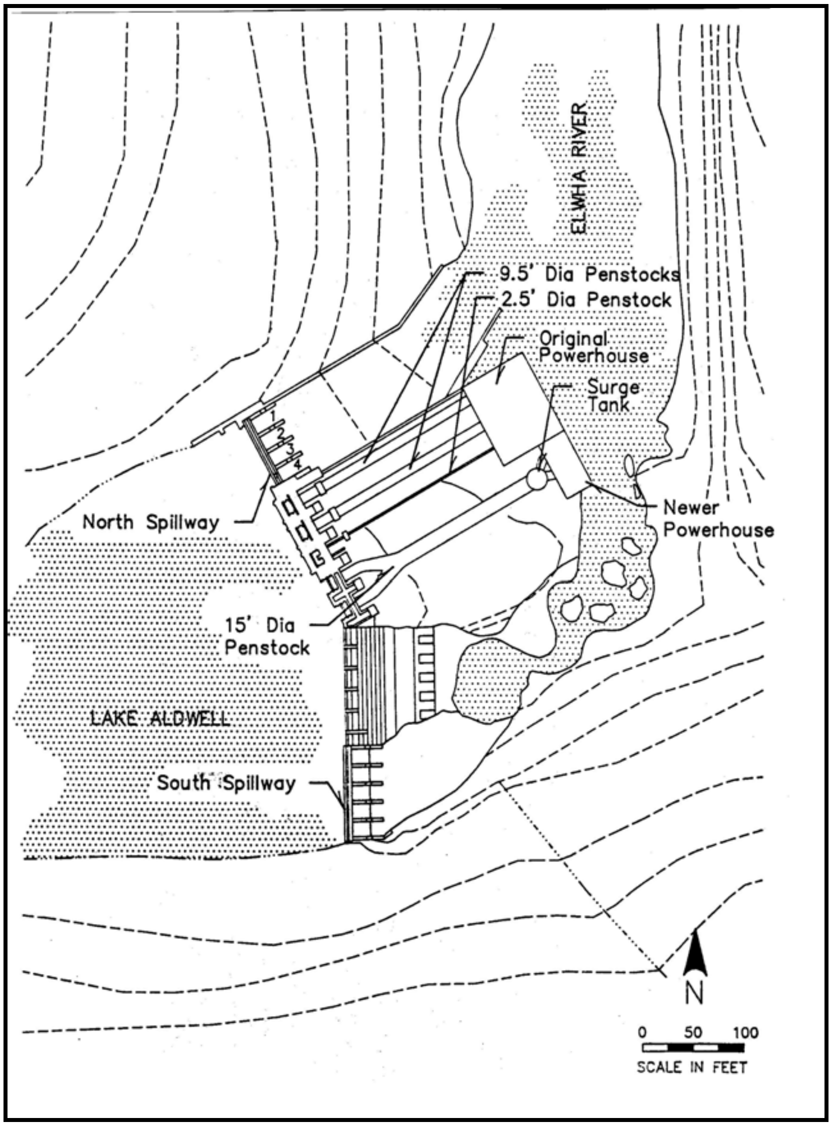

Figure 2. Site plan for Elwha Dam and powerhouses (from FERC 1993).

The Glines Canyon Hydroelectric Project was built from 1925-1927 at RM 13.1. The dam is a varied radius, single arch concrete structure that is 210 feet high and 270 feet at its crest. It has a single spillway on the left bank and there is only one vertical Francis turbine in the powerhouse (Figure 3). The installed capacity of this project is 13.1 MW (FERC 1993). The associated reservoir, Lake Mills, has about 30,000 acre-feet of active storage. The dam has a small low-level outlet, but it has not been used since construction of the dam.

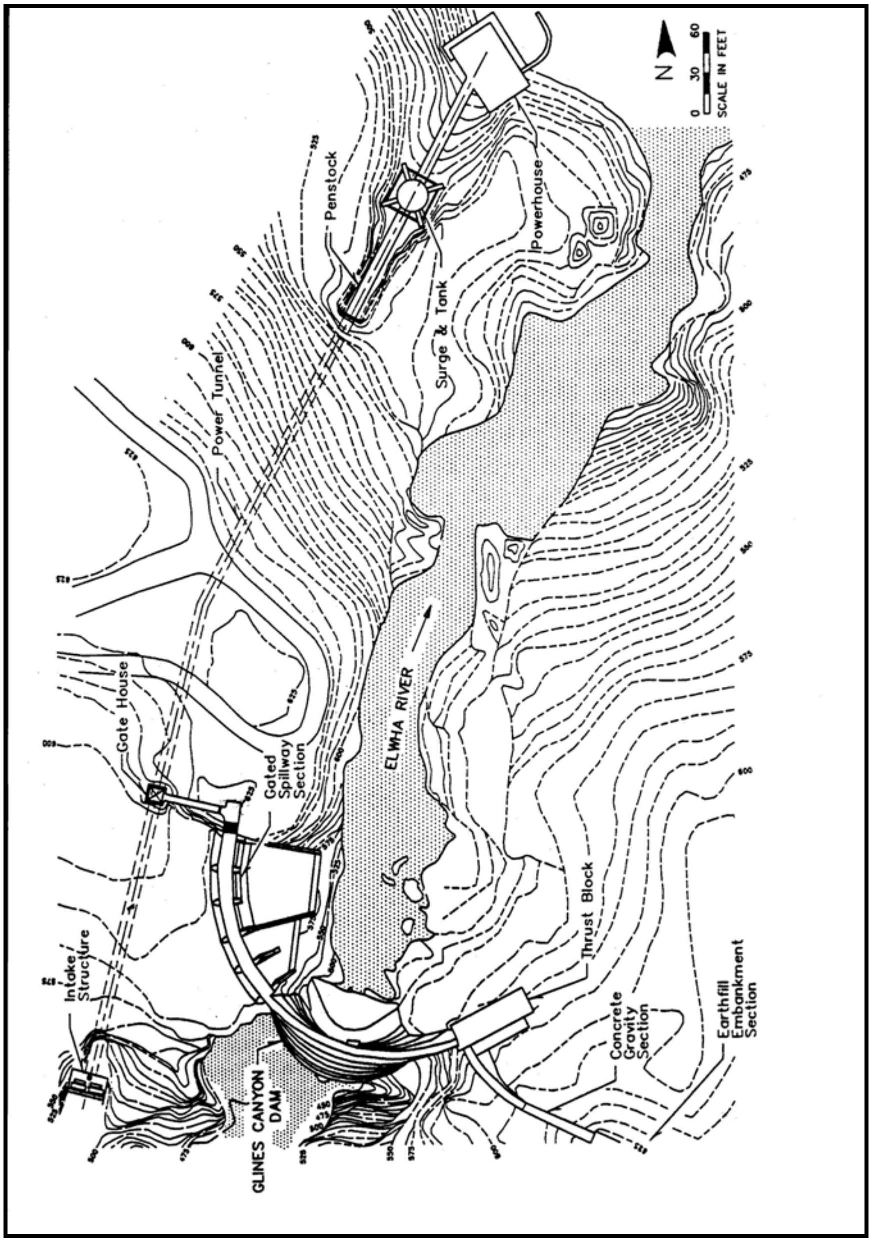

Figure 3. Site plan for Glines Canyon Dam and powerhouse (from FERC 1993).

The first stage in removal of the two dams is the draining of Lake Mills 80 feet using the existing power outlet. This will allow for some flood protection as a temporary diversion channel is constructed through the left abutment at Elwha Dam (ONP 1996). Once the diversion is completed, Lake Aldwell will be drained about half its depth and coffer dams constructed to isolate the area behind the concrete gravity section. This will allow for removal of the concrete gravity structure and the fill that was placed behind the dam when the foundation failed during filling of the reservoir in 1912 (Aldwell 1950). The historic river channel will be restored following removal of the dam and the fill material. The coffer dams will be removed in a controlled manner, the remaining reservoir drained, and the river channel reestablished.

Glines Canyon Dam will be removed concurrently with Elwha Dam. Once the temporary diversion channel is in operation at Elwha Dam, the upper 80 feet of the concrete gravity arch structure will be removed by cutting blocks out with a continuous diamond wire saw or with controlled blasting (ONP 1996). At this point, the reservoir will be drained over the remaining dam structure by cutting notches into the face of the dam and removing additional levels of concrete. The removal of both dams will take about 2.5 years, primarily because of limitations imposed by the sediment management plan (see below).

Sediment Management

Approximately 18 million yd^3 of material have accumulated within the two reservoirs since construction of the dams. This material is composed of 9.2 million yd^3 of highly erodable silt and clay, 6.2 million yd^3 of moderate to highly erodable sand, and 2.3 million yd^3 of more slow moving gravel and cobble (ONP 1996). Most of the coarse sediment is located in a delta at the heads of Lake Mills that reaches depths of up to 70 feet. The fine material is more evenly distributed over the bottoms of both reservoirs, in some places up to 10 feet deep.

The river will be allowed to move this material downstream, although much will remain within the former reservoir areas. Up to 60% of the fine material will erode downstream within a three to five year period during and following dam removal while only up to about 30% of the coarse material is estimated to leave the reservoir areas over a much longer time.

Release of the coarse sediment downstream will replace material eroded from below the dams over the past 90 years so is a beneficial aspect of the sediment management plan. In particular, the river has armored with large size cobble so the release of spawning sized gravel will help restore the lower river to allow fish restoration to occur.

The fine material can also be considered a resource, but release of 90 years worth of accumulation will greatly exceed safe limits for fish. Therefore, the dam removal contractor will be required to cease dam removal activities during the peak spring downstream migration period, the peak entry timing of chinook salmon, and the peak entry timing of coho, pink, and chum salmon. These closures total approximately 5.5 months each year although high stream flow events will also cause the contractor to cease work until flows recede. The closures are referred to as “fish windows” and are critical to the success of the fish restoration program (see below).

Release of large quantities of fine materials will also affect downstream municipal (City of Port Angeles) and industrial water users as well as two fish hatcheries. Water mitigation facilities are planned to protect these users during the dam removal period. The details of these efforts will be further analyzed in a supplemental environmental impact statement that will be released in 2004.

Fish Restoration

Remaining anadromous fish in the Elwha River are a combination of hatchery propagated and naturally spawning stocks (Wunderlich et al. 1994). The fish restoration program includes protection of the stocks during dam removal, hatchery propagation and outplanting following dam removal for a period of 10 years, and monitoring and harvest management to ensure adequate returns (ONP 1996).

The working assumptions of the fish restoration plan include the following (ONP 1996; Wunderlich 1994):

- The two hatcheries can serve as fish refuges during dam removal.
- The “fish windows” will permit escapement to hatcheries or other clean water areas as well as allowing capture within the river.
- Hatchery outplanting will speed re-colonization and allow selective re-introduction of stocks.
- Hatchery outplanting at very early life stages will improve long-term survival of stocks.
- Natural re-colonization is a “fail-safe” long-term restoration measure for all stocks.

Protection of the water supplies for the two fish hatcheries will essentially allow them to serve as refuge for fish during the high sediment release period. The fish windows were designed to allow adequate numbers of adult fish to return to the river rather than risk avoidance of the river mouth because suspended sediment levels could be too high. Once the fish return to the river, as many as possible will be captured and placed in the two fish hatcheries to protect them from the high suspended sediment concentrations expected to occur outside of the fish windows.

The fish will be spawned in the hatcheries and the resulting progeny released from those facilities during dam removal (within the appropriate fish window) to migrate downstream. Following dam removal, fish will still be captured, spawned in the hatcheries, and the progeny released within the river after transport upstream by helicopter, deep within Olympic National Park or by truck below the site of Glines Canyon Dam.

Scientific peer reviews of the proposed fish restoration plan (see ONP 1996) has resulted in refinements to the plan. Improvements include multiple outplanting strategies and improved monitoring to document the success or failure of the different strategies. Adaptive management will likely be required to successfully restore each of the fish stocks.

Public participation in the fish restoration program will be actively pursued. Opportunities to assist include the collection and transport of fish during the fish windows, help with fish transport and outplanting activities following dam removal, and stream surveys to document the success of the program.

Revegetation

Prior to reservoir filling, the hill slopes were clearcut and the valuable timber from the floodplain areas was harvested. The focus of the plan to revegetate these areas is to achieve old growth characteristics as quickly as possible, with the ultimate goal of managing the restored area within Olympic National Park as wilderness.

The revegetation plan includes many component actions beginning before dam removal, during draining of the reservoirs, and following complete removal of the dams (Table 1). Grow trials using fine sediments (primarily a mixture of silts and clays) obtained from the bottom of Lake Mills were conducted to determine the ability of these materials to support native vegetation. The grow trials and chemical analyses of the sediments indicated that these fines are nutrient poor and provide an unsuitable substrate for most plant species, although red alder readily, albeit with slow initial growth, takes hold in this material and, with its nitrogen fixing characteristics, would prepare the soil for later successional species.

The greatest depths of these fine sediments are along the reservoir bottoms. While up to approximately two thirds of this material will be eroded downstream, much will remain within the floodplain areas. Fine sediments along the currently inundated hill slopes are expected to erode down slope during the slow process of reservoir drawdown, but some active manipulation may be necessary to expose the original soil surface, or close to it. Native trees and other vegetation will be planted along these exposed slopes as the reservoirs are drained. The exposed floodplain areas will be allowed to revegetate naturally since this area will be relatively unstable for many years as the river adjusts to its historic gradient.

Seeds and cones from Douglas fir (*Pseudotsuga menzeisii* var. *menzeisii*) and grand fir (*Abies grandis*) have already been collected and are currently in storage. Seeds and cuttings from other native plants will also be collected to provide root stock for the planting program (ONP 1996).

One of the major components of the revegetation plan is the control of nonnative invasive species. Many nonnative plants are present within the watershed, including English holly *(Ilex aquifolium*), Scot's broom (*Cytisus scoparius*), common chickweed (*Cerastium fontanum*) and Canada thistle (*Cirsium arvense* var. *horridum*), among many others (ONP 1996).

Public volunteers were used during the cone collection activities and opportunities will be available to assist with the planting and nonnative invasive species management programs.

Table 1. Summary of actions to reestablish native vegetation within the drained areas of Lake Mills and Lake Aldwell.

Timing[1]	Revegetation Actions
Before	Conduct grow trials using reservoir bottom sediments.
Before	Collect seeds and cones within the watershed.
During & After	Relocate coarse woody debris for recolonization.
During & After	Employ biotechnical slope stabilization, as needed.
During	Seed and plant hill slopes as reservoirs drain.
After	Rely on natural recolonization of reservoir beds.
After	Control and remove nonnative invasive plants.
During & After	Monitor effectiveness.
After	Implement remedial measures, as needed

[1] *Before, during, and after dam removal activities.*

Conclusion

Removal of the Elwha and Glines Canyon dams is a project with many large construction related aspects. Public participation in these activities is necessarily limited. However, the revegetation and fish restoration programs offer many opportunities for public participation and involvement. In addition, they provide a wonderful opportunity to teach people about various aspects of ecosystem restoration which potentially far reaching benefits. The Elwha River Restoration Project does not yet have a volunteer outreach program or coordinator, but I hope that will be remedied before dam removal commences in 2007.

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Responses of Streams to Riparian Restoration in the Spring Creek Watershed, Central Pennsylvania

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ABSTRACT—Sediment originating from intensively grazed pastures was linked to depressed reproduction of brown trout *Salmo trutta* in Spring Creek, a limestone stream in central Pennsylvania. The Spring Creek Chapter of Trout Unlimited with support of public agencies initiated a project in 1990 that was designed to restore degraded riparian areas and reduce sediment loading. Improvements included stabilizing eroding stream banks, installing rock-lined animal accesses and stream crossings, and constructing fences along the streams.

Spring Creek was divided into three major regions for this study: (1) the upper region was comprised of the Slab Cabin Run basin, the Cedar Run basin, and the upper Spring Creek basin; (2) the middle reach of Spring Creek, where reproduction of brown trout had been depressed; and, (3) the lower reach of Spring Creek. Restoration efforts were concentrated in two tributaries in the upper region. There were 2.55 miles of stream flowing through unfenced riparian pastures in the Slab Cabin Run basin, and 67% of this stream length was improved and well maintained through 2003. There were 1.55 miles of stream flowing through unfenced pastures in the Cedar Run basin, and 98% of this stream length was improved and well maintained through 2003. Upper Spring Creek, which had no unfenced riparian pastures, was used as a reference. Similar restoration efforts were applied to six properties on the middle reach of Spring Creek.

The primary objective of this study was to quantify the effects of stream bank fencing and stabilization in Slab Cabin Run and Cedar Run. We measured channel morphology, substrate composition, stream temperatures, discharge, water quality, macroinvertebrate, and fish communities prior to restoration in 1991-1992. Restoration activities were completed in 1992-1998, and post-restoration assessments were made in 2001-2003. A secondary objective was to quantify brown trout spawning activity in the middle reach of Spring Creek prior to and after riparian restoration activities.

Stream bank fencing resulted in re-vegetation of eroded banks with primarily grasses and a few shrubs. No trees were planted, and none invaded the buffer zone. Stream channel morphology did not change after restoration. Total suspended solids during base flow in Cedar Run declined by 36 to 45% and in Slab Cabin Run total suspended solids declined by 77 to 82% after restoration, though below-average discharge contributed somewhat to these reductions. During storm flow there were significant reductions in total suspended solids in one of two years in Cedar Run and in both years in Slab Cabin Run. There were no significant changes in concentrations of nitrogen or phosphorus after restoration. The amount of fine sediments in the substrate of Cedar Run declined after restoration, but similar changes were not evident in Slab Cabin Run. There was no indication that stream temperatures changed as a result of stream bank restoration. Composition of the macroinvertebrate communities did not change,

but there were significant increases in densities of macroinvertebrates after restoration. Composition of the fish communities and densities of wild brown trout in Cedar Run and Slab Cabin Run were similar before and after restoration.

We conducted redd surveys on 34 miles of Spring Creek in 1988 and 1989 and after restoration in 1997-2000 and 2002. Numbers of brown trout redds in the middle reach of Spring Creek increased by 460% after restoration. During this same period, numbers of brown trout redds in the upper reach of Spring Creek decreased by 35% and in the lower reach of Spring Creek increased by 33%. Density of age-1 and older brown trout increased by 125% in 2000 compared to 1988 in the middle reach. During these same years, density increased by 10% in the upper reach and by 58% in the lower reach.

We concluded that riparian restoration along the tributaries led to re-vegetation of eroded banks, reductions in total suspended solids, and increases in densities of macroinvertebrates. This reduced sediment loading apparently benefited an 8-mile reach of the main stem, where brown trout redds increased substantially.

Managing Brook Trout Populations in an Urbanizing Environment

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ABSTRACT—Urbanization effects, from an increasing human population, threaten all mid-Atlantic trout populations. Currently, Maryland is experiencing acute anthropogenic problems that are particularly severe in Maryland's Northern Piedmont ecoregion, an area of significant precolonial native *Salvelinus fontinalis* (brook trout) populations, but now containing only remnant and highly fragmented populations. These relic populations are highly vulnerable to urbanization stresses, and many may become extinct in the near future. Employing primarily Maryland Biological Stream Survey (MBSS) data, we determined urbanization effects on Maryland brook trout streams, focusing principally on the Northern Piedmont ecoregion. Combining GIS with the MBSS data set, landscape-based urban characteristics, including watershed impervious surface, road density, roads near streams, forest fragmentation, and others were examined to determine effects on stream community structure. We also investigated brook trout population fragmentation, exotic species effects, and stream connectivity. Impervious surface greater than 0.3% in a watershed effectively eliminated brook trout populations, with urbanization, road density, and roads near streams severely affecting stream community structure. Effective brook trout management plans need to be developed to specifically address urbanization effects in the Northern Piedmont ecoregion.

Introduction

When human population reaches a critical threshold within a watershed, the "urban syndrome" prevails (Paul and Meyer 2001), effecting complex alterations on biotic, chemical, and physical watershed characteristics and processes that result in generally degraded streams with subsequent biotic alterations (Wang et al. 1997, Roth et al. 1999, Wang and Kanehl 2001, Paul and Meyer 2001, Brabec et al. 2002, Gergel et al. 2002, Groffman et al. 2003, Center for Watershed Protection 2003). Urbanization effects are a major contributing factor affecting biotic assemblages worldwide (Forman and Alexander 1998, Forman et al. 2003, Paul and Meyer 2001). Paul and Meyer (2001) state that urbanization is second only to agriculture as a major causative agent to stream degradation in the United States (USEPA 2000). From destroying intermittent and perennial low order streams, increasing impervious surface area, changing hydrological regimes, elevating nutrients and contaminants to altering biotic assemblages, urbanization is a major stressor that is difficult to mediate, and reverse, once it becomes watershed dominant.

Numerous studies have determined that landuse change within a watershed affects stream fish populations (e. g. Fraker et al. 2002), but there are limited studies in the literature that examine fish assemblage and community responses to urbanization, and even fewer that address coldwater species (Kemp and Spotila 1997). For example, Paul and Meyer (2001) list only six studies that specifically deal with biological responses of fish to urbanization (primarily impervious surface). Most studies generally found significant changes in either fish diversity or fish indexes of biotic integrity (IBI) correlated to either increasing impervious surface or urban land use in the watershed (Klein 1979, Steedman 1988, Schueler and Galli 1992, Weaver and Garman 1994, Wang et al. 1997 and Yoder et al. 1999), with the overall conclusion that significant biotic changes occur at watershed impervious values of 10-12%.

In this paper, we address urbanization effects on brook trout populations in the Northern Piedmont ecoregion (EPA Level III) of Maryland—an area bounded by the Southeastern Plains ecoregion to the east, and the Blue Ridge ecoregion to the west. The Northern Piedmont ecoregion is subject to increasing urbanization stress due to population growth along the Baltimore - Washington corridor.

Methods

MBSS data (Roth et al., 1999) from 1995-1997 (first round) and 2000-2002 (partial second round) for trout populations in Maryland were used with ESRI software (ArcView 3.2 and ArcView Spatial Analyst Version 1.1) to examine trout population attributes and to calculate various landscape variables (first round MBSS data only) for streams in the Northern Piedmont ecoregion (Holt 2003). This ecoregion includes sections of the Susquehanna, Bush, Gunpowder, Patapsco, Patuxent, Potomac Washington Metro and Middle Potomac basins (Roth et al. 1999).

GIS layers included watershed delineations, elevation, land use/land cover (LULC), hydrographic data, and roads; Maryland State Plane coordinate system and NAD 1983 geographical datum were selected to format all GIS data. Shape files were obtained from the MBSS containing polygons representing the drainage area for each station in the 1995-1997 MBSS public dataset. LULC data was obtained from the National Land Cover Dataset derived from Landsat Thematic Mapper imagery. Landscape watershed characteristics generated included proportional land coverage (%) with urban, agriculture, forest, barren, and wetland (Holt 2003); other parameters included riparian urban, riparian agriculture, riparian forest, riparian barren, riparian wetland, agriculture on steep slopes, forest fragmentation on steep slopes, road density, roads near streams, municipal sewage loadings, and basin size (Holt 2003). Nested stations with overlapping watershed areas were removed from the data set, thus ensuring independent data and eliminating pseudoreplication.

Random (quantitative) and non-random (qualitative) MBSS locations were plotted on a Maryland stream reach map that was derived from the 1:100,000 scale National Hydrography Dataset. The stream reach length was recorded for every first to third order stream reach (above the fall line) where brook trout were collected by the MBSS. Stream reach lengths were also recorded for stream reaches where brook trout and other species of trout were collected and for stream reaches where no brook trout were collected. Stream reach lengths, not sampled by the MBSS upstream of stream reaches where brook trout were collected, were recorded as stream reaches where brook trout were possibly or probably present. All MBSS sites for the Northern Piedmont ecoregion, with either greater than 65% agriculture or any wastewater treatment plant present, were removed from the data set prior to analyses of landscape-community relationships (effective number of MBSS sites remaining equaled 153). Statistical techniques for derived MBSS data sets included regression analyses and ANOVA, using Statistica, Stata, and SAS programs.

Results

Within the six drainage basins occurring in the Northern Piedmont ecoregion, only the Susquehanna (20% of stream miles) and Gunpowder (22%) still support significant extant brook trout populations, with residual populations present in the Patapsco (3.4%) and Patuxent (0.6%) drainages (Table 1). Three drainages no longer contain brook trout.

Table 1. Summary of stream length analyses for brook trout streams in the Northern Piedmont ecoregion of Maryland (1 = first order stream; 2 = second; 3 = third).

Basin	Brook Trout (Exotics) (km)	Possible Brook Trout (km)	No Brook Trout (km)	Total Stream Length (km)	% Total Steam Length with Brook Trout
Susquehanna	1. 23 2. 8.6	1. 45 2. 5.7 3. 5.0	1. 263 2. 59 3. 29	1. 332 2. 73 3. 34	1. 20.6 2. 19.5 3. 14.6 Overall % = 20.0
Bush			1. 100 2. 22 3. 30	1. 100 2. 22 3. 30	1. 0 2. 0 3. 0 Overall % = 0
Gunpowder	1. 50	1. 38 2. 6.9	1. 314 2. 25	1. 402 2. 32	1. 21.8 2. 21.7 Overall % = 21.8
Patapsco	1. 11 2. 3.3	1. 9.3 2. 2.2	1. 501 2. 153 3. 83	1. 521 2. 159 3. 83	1. 3.9 2. 3.5 3. 0 Overall % = 3.4
Patuxent[1]		1. 2.2	1. 293 2. 59 3. 48	1. 295 2. 59 3. 48	1. 0.75 2. 0 3. 0 Overall % = 0.55
Potomac Washington Metro			1. 471 2. 145 3. 65	1. 471 2. 145 3. 65	1. 0 2. 0 3. 0 Overall % = 0
Middle Potomac[1]			1. 1,036 2. 224 3. 153	1. 1,036 2. 224 3. 153	1. 0 2. 0 3. 0 Overall % = 0

[1]*Only one possible brook trout population (2.2 km) remains in the northern Patuxent basin—this needs to be confirmed through additional sampling.*

[2]*The Middle Potomac abuts onto the Blue Ridge ecoregion of Maryland where significant populations of brook trout are present—these populations may extend slightly into the Middle Potomac drainage.*

Using basically the same assumptions for Maryland brook trout as listed in Roth et al. (p. 4-21, 1999) and an estimate of 0.35 brook trout/m, we calculated that the precolonial Northern Piedmont ecoregion held 1.6 million brook trout, but currently holds only 0.081 million fish, or 5.2% of the precolonial population estimate. However, this estimate may be skewed since it is an average based on selected MBSS brook trout sites assumed to be most analogous to historical conditions (Roth et al. 1999). Utilizing population data collected from western Maryland trout streams from 1988-1990, we estimated precolonial and current brook trout numbers (Morgan 1988, 1989, 1999). This analysis, using an exponential distribution function (N = 111) for the number of trout/m and stream meters/basin, yielded a precolonial estimate of 1.3 million brook trout. Extant populations in the Northern Piedmont ecoregion now total 0.070 million brook trout (95% confidence interval = 42,400—98,200 trout)—both our precolonial and extant estimates are slightly lower, but in close agreement with Roth et al. (1999).

For brook trout streams in the Northern Piedmont ecoregion, stream fragment length did not vary significantly (ANOVA, $p = 0.39$, $F = 1.01$, $df = 3, 149$) among the three basins (Savage River watershed in western Maryland employed as a control watershed), with mean fragment length ranging from 2.0—2.8 km (Table 2). However, each of the three Northern Piedmont basins contained a number of stream fragments at risk (based on isolation from other brook trout populations or the presence of competitive exotic trout species). In addition, there were a number of brook trout subpopulations, within each basin, that had become compressed (Table 2). Usually, compression of a brook trout subpopulation resulted from the presence of an exotic species in the lower section of a stream segment, isolation due to the presence of exotic species in nearby stream reaches, or the presence of physical barriers. Both brook trout in stream fragments at risk and compressed subpopulations are vulnerable to extinction in the near term.

We also examined a number of landscape parameters that could potentially affect brook trout populations in the Northern Piedmont ecoregion. A piecewise linear regression model, comparing brook trout density with impervious surface within the site watershed, explained 76% of the variance (Table 3). In the

Table 2. Summary of stream fragment analyses for brook trout streams in three basins of the Northern Piedmont ecoregion of Maryland (Savage drainage used as comparison).

Basin	Mean Fragment Length (km) and Number	Fragments at Risk	Number of Compressed Populations
Susquehanna[1]	2.8 / 30	10	10
Gunpowder	2.8 / 43	25	7
Patapsco	2.0 / 13	8	5
Savage	2.7 / 67	0	0

[1] One small population of brook trout (Winch Run) was sampled on 931116 (ymd), and is now extinct.

Table 3. Summary of piecewise linear regression model (least squares), with estimated breakpoint (N = 103). BT = brook trout/m^2 and WIS = watershed impervious surface.

Estimated b_{01}	WIS_1	Estimated b_{02}	WIS_2	Breakpoint
0.0808	-0.0189	0.532	-0.998	0.27
BT_1 = 0.0808—0.0189(WIS)		BT_2 = 0.532—0.998(WIS)		R = 0.87

Maryland State of the Streams Report, Roth et al. (1999) stated that the majority of Maryland brook trout populations were found in watersheds with less than 0.5% impervious surface, and that no brook trout were collected from those watersheds with greater than 2% impervious surface. Results from the current analyses agree very well with the previous conclusions in Roth et al. (1999), although our estimated statistical breakpoint was 0.27% watershed impervious surface, approximately one-half of the previous estimate of 0.5% (Table 3).

In this study using both 1995-1997 and 2000-2002 MBSS data, there were eight brook trout populations found at an impervious surface intensity greater than 0.5%, with three brook trout populations present in watersheds with over 2.0% impervious surface (highest = 3.2%). However, brook trout density in these eight populations averaged only $0.038/m^2$ (SE = 0.013), or 24% of the mean density for all 103 brook trout only populations combined, indicating that brook trout populations may exist at higher impervious surface levels, although raising questions of long-term population survival at these very low densities.

In addition, we compared the density of the 103 brook trout only populations with an additional 33 brook trout populations that had exotic trout present, predominantly *Salmo trutta* (brown trout) and infrequently *Oncorhynchus mykiss* (rainbow trout). There was a significant difference ($p = 0.0020$, $t = 3.2$, $df = 134$) between the two groups, with brook trout only populations equal to a density of $0.16/m^2$ (SE = 0.019) and brook trout and exotic species present equal to $0.050/m^2$ (SE = 0.011)—a reduction of ~70%. The mechanism for this density difference is not known, although it may be a combination of interspecific competition and landuse change (Fausch 1988).

Although watershed impervious surface appears to be a critical factor for brook trout sustainability in urbanizing regions, we found other landscape parameters associated with stream benthic community structure to be very important (Table 4). Using regression analyses, cutpoint estimates were made for four key benthic parameters using MBSS BIBI cutpoints (all highly significant regressions - $p < 0.0000$ ranged from 0.18 to 0.38 r^2). While there were a number of significant correlations among all landscape variables, urban, urban riparian, road density and roads near streams were selected for further analyses.

Table 4. Analyses of landscape and community biological parameters for the Northern Piedmont ecoregion, with estimates made using regression analyses. Urban = proportion of watershed with urban land cover; urban riparian = proportion of watershed with urban land cover adjacent to stream edge; road density = average number of km of roads per km^2 of watershed; and roads near streams = proportion of total stream length having roads within 30 m. MBSS cutpoint used was the upper breakpoint between a score of 1 and 3; BIBI is the Maryland benthic index of biotic integrity (non-coastal plain).

Biological Metric/ (MBSS Cutpoint)	Landscape Parameter			
	Urban	Urban Riparian	Road Density	Roads near Streams
Total Taxa (15)	29%	15%	6.6	9%
EPT Taxa (4)	36%	22%	7.6	13%
Intolerant Species (2)	40%	24%	8.2	13%
BIBI (2.9)	10%	4%	3.8	5%

For the first three individual metrics, all were higher estimates than observed for the BIBI alone (Table 4). However, using a BIBI value of 2.9, where the cutpoint from poor to good equals 3.0, the four landscape parameters define maximum urbanization levels for brook trout sustainability within a watershed. To protect, or to perhaps restore, a brook trout stream, the watershed must have an urban land cover less than 10%, an urban riparian cover less than 4%, and a total stream length of roads within 30 m of less than 5%. In addition, the watershed road density must be below 3.8 km/km^2. Sixteen (12%) of the MBSS brook trout sites had BIBI values less than 2.9; however, trout density averaged 0.025 trout/m2 at these sites—a possible response to poor stream food quality.

Discussion

Three important processes fragmentation, compression, and extinction of brook trout populations are occurring as a result of increasing urbanization in the Northern Piedmont ecoregion of Maryland. Fragmentation and compression reduce effective brook trout population size, and accelerate extinction, or at the very less, an increased extinction probability (Gilpin and Soule 1986). In addition, structural changes in stream trophic levels due to urban effects may expedite these three processes. Urbanization also affects Maryland brook trout populations through the loss of both evolutionary equity and evolutionary services through population reduction and loss of unique genetic variability (Morgan and Danzmann 1998, Hall et al. 2002).

Urbanization is an acute problem in Maryland, especially with increasing development along the Baltimore - Washington corridor in the Northern Piedmont ecoregion. From 1970 to 2000, the human population in Maryland increased from 3.9 to 5.3 million, with a projected population increase from 5.3 million (2000) to 6.3 million in 2025, further saturating an expanding urban environment with an additional million people in approximately 25 years. In recent years, the landscape in mid-Atlantic ecoregions, especially the Southeastern Plains (Coastal Plain of Maryland) and Northern Piedmont have experienced significant changes, resulting in increased forest fragmentation and forest cover loss that affect stream processes (Griffith et al. 2003).

Effective management of native brook trout populations in the Northern Piedmont ecoregion is problematical due to increasing urbanization of the landscape. To facilitate brook trout management in urban environments, a few specific management recommendations may be made based on the results from the Northern Piedmont ecoregion of Maryland (Table 5). Although these apocalyptical recommendations are not to be all-inclusive management options, they serve as a starting point to protect brook trout populations in rapidly growing urban areas that have brook trout present.

Table 5. Urban specific brook trout management recommendations for the Northern Piedmont ecoregion of Maryland.

Impervious surface	Limit impervious surface within a coldwater watershed to less than 0.5%, and minimize road density.
Roads	Eliminate all parallel streamside roads within 200 meters of a stream, minimize stream crossings (perpendicular bridge crossings only and no culverts), and eliminate all road and urban storm water runoff.
Exotics	No stocking of any exotic trout species within a brook trout dominated watershed.
Riparian Buffer	Maintain, or restore, minimum streamside buffer of 200 meters (or greater)—no timber harvest in riparian buffer. Increase connectivity of urban riparian buffers, and reduce sediment input.
Groundwater	Limit, or eliminate, groundwater removal in urban watersheds with brook trout to maintain springs and seeps.

However, there remains one looming specter threatening brook trout populations throughout Maryland, and all brook trout in the southern Appalachians, even if major efforts were made to protect urban coldwater streams. Climate change may well lead to increased fragmentation of brook trout populations (Flebbe 1997, Meisner 1990), resulting in an increasing extinction probability. For Maryland, the climate warming model, developed by Meisner (1990), predicts that brook trout will be confined to only the western two counties, and all eastern Maryland brook trout will be extinct. If that prediction does occur over the next 100 years, it will represent a loss of genetically unique brook trout populations, and may result in alternative coldwater management techniques in eastern Maryland, using non-native coldwater and coolwater species.

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Lessons Learned from Trout Unlimited's Watershed Programs

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ABSTRACT— Since 1994 Trout Unlimited (TU) has launched more than a dozen large-scale watershed restoration projects through its Watershed Programs. Projects fall under several programs including the Home Rivers Initiative, which focuses on private lands, and Bring Back the Natives and Strategies for Native Trout, both public lands programs. All projects are collaborative multi-year efforts that combine scientific and economic research; community outreach; on-the-ground restoration; and the development of long-term conservation and management strategies and tools. TU has a strong record of accomplishment tackling a range of restoration challenges in diverse regions of the country and has some unique perspectives to share. Interviews with project mangers reveal the importance of number of factors, including the pivotal role of partnerships, the pros and cons of the range of management arrangements, the challenges of working with landowners, the importance of outreach efforts, and frustrations related to funding, to name but a few. As a national-level nongovernmental institution convening locally based projects, TU fills a unique niche. They bring credibility to local conservation efforts, flexibility to act where others are not able, and often serve as a bridge among organizations and between landowners and government agencies.

Introduction

In 1994 Trout Unlimited (TU) began its experiment with large-scale watershed restoration projects when it launched the first Home Rivers Initiative on the Beaverkill-Willowemoc River system in New York. Since the early 1990s, many organizations have been testing the "new" approach to watershed restoration. Top-down government management and a narrow focus on the river corridor had previously characterized restoration and protection efforts. The new approach uses the entire watershed as the unit of analysis and management, relies on sound science to guide decisions, and most notably utilizes collaborative consensus-driven arrangements among multiple levels of agencies, the local community, and other partners to coordinate resources, information, and activities. Local organizations or government agencies commonly catalyze these initiatives (Born and Genskow, 2001). Some national level organizations have resisted becoming involved in collaborative watershed efforts for fear of being co-opted or not being in control while sitting across the table from traditional "enemies" (Huntington and Sommarstrom 2000). Therefore, TU is somewhat distinctive in its experience.

In the intervening years, the national office of TU has implemented more than a dozen watershed restoration projects across the country under the auspices of several programs that address an impressive array of restoration challenges (Figure 1, Table 1). The Home Rivers Initiative focuses primarily on private lands and is our flagship watershed restoration program. Bring Back the Natives (BBN) is a grant program established to fund restoration of native aquatic species and their habitats on public lands. Founded in 1991, it is a partnership between

TU and the National Fish and Wildlife Foundation, Bureau of Land Management, US Forest Service, Bureau of Reclamation, and U.S. Fish and Wildlife Service. In 2001 the BBN program was reoriented to focus on watershed-scale conservation efforts based on the results of an assessment conducted by TU (Harig and McGurrin). Strategies for Native Trout (Strategies), a partnership program similar to BBN, was initiated in 2001 to address some of the most pressing information needs in large-scale restoration of inland native trout, and focuses on monitoring and evaluation of several native trout projects. In addition, TU has initiated a number of other large-scale restoration initiatives that follow the watershed programs model but focus on a broader region or multiple rivers.

All the programs adhere to the principles of the new watershed approach. In using this approach, TU selects watersheds where we can both make a significant difference in the condition of the particular river or fishery, and demonstrate innovative and transferable restoration strategies and techniques. This has led to some impressive successes on issues such as acid mine drainage, western water flows, and native species restoration efforts. In just a few short years, TU's Watershed Programs have grown to become one of the organization's largest and most visible programs.

After a decade of work in numerous locations around the country, it is fitting that TU assemble the lessons learned for both its own internal benefit, and so other organizations and agencies involved with watershed restoration may gain from our experiences. There have been a number of other efforts to collect case studies and evaluate collaborative approaches to watershed restoration (Born and Genskow 2001; Huntington and Sommarstrom 2000; USDA Forest Service 2003; Williams et al. 1997). TU's own findings corroborate many of the broader lessons learned in these other studies, but also offer unique insights.

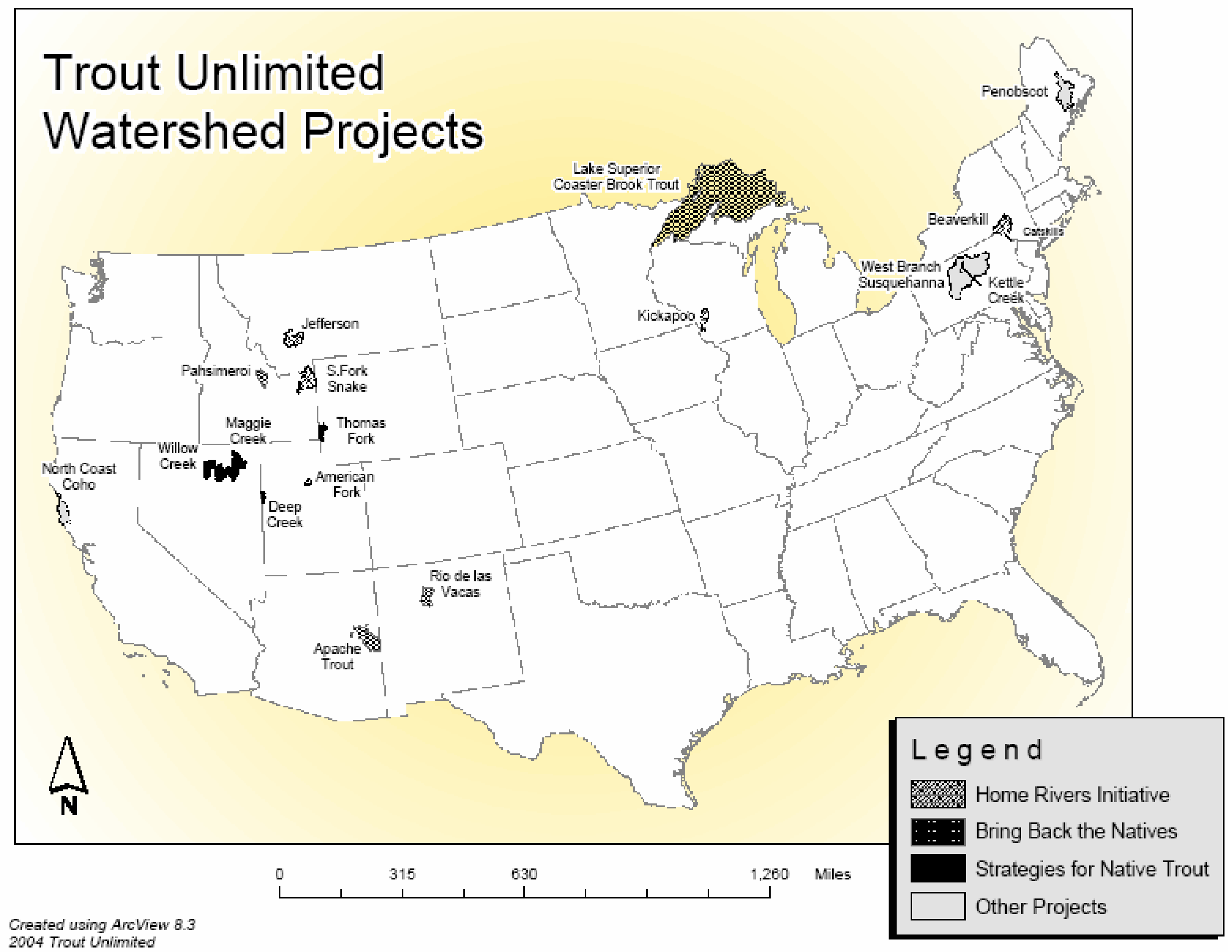

Figure 1. Locations of Trout Unlimited's Watershed Projects.

Table 1. Summary of TU Watershed Projects

Project Site	Program	Year Initiated	Target Trout Species	Primary Conservation Focus
Beaverkill River, NY	HRI	1994-2001	Brown, Rainbow	Assessment, Stormwater Flows
Kickapoo River, WI	HRI	1996-1999	Brook*, Brown	Channel Restoration, Land Use, Native Species Reintroduction
Kettle Creek, PA	HRI	1998	Brook*, Brown	Acid Mine Drainage Remediation, Channel Restoration
Jefferson River, MT	HRI	2001	Brown	Drought Planning, Irrigation Efficiency, Spawning Channel Improvement
S. Fork Snake River, ID	HRI	2001	Yellowstone Cutthroats*	Stream and Dam Flows, Tributary Reconnections, Hybridization
American Fork River, UT	HRI	2004	Bonneville Cutthroats*	Abandoned Hard Rock Mine Remediation
Pahsimeroi River, ID	BBN	2003	Bull*	Tributary Reconnection, Irrigation Efficiency
Lake Superior, MN/WI/MI	BBN	2003**	Coaster (migratory) Brook*	Harvest Regulations, Habitat Improvement, Remnant Stock Protection
Rio de las Vacas, NM	BBN	2003	Rio Grande Cutthroat*	Exotic Management, Road Retirement
Black, White, and Little Colorado Rivers, AZ	BBN	2003	Apache*	Exotic Management, Riparian Habitat Improvement
Thomas Fork, ID/WY	Strategies	2001	Fluvial Bonneville Cutthroats*	Barrier Removal, Habitat Restoration, Monitoring
Maggie Creek, NV	Strategies	2001	Lahontan*	Barrier Removal, Monitoring
Willow Creek, NV	Strategies	2004	Lahontan*	Grazing Management, Habitat Restoration, Monitoring
Deep Creek, UT/NV	Strategies	2001-2003	Bonneville Cutthroat*	Exotic Management, Native Species Reintroduction, Monitoring
North Coast, CA	Other	1998	Coho Salmon*	Sediment Reduction, Stream Restoration
Catskills Initiatives, NY	Other	2001	Brown, Rainbow	River Flows, Stream Restoration
Penobscot River, ME	Other	2003	Atlantic Salmon*	Dam Removal
W. Branch Susquehanna River, PA	Other	2004	Brook*	Acid Mine Drainage Remediation

**Native species*

***TU has been working in Lake Superior on Coaster issues since 1992. We received BBN funding in 2003.*

Methods

Semi-structured phone interviews were conducted with all of TU's current and most past watershed program staff. Fifteen interviews were conducted during July 2004. Each person was asked a standard set of questions on a range of topics including; project scope and scale, role of science and assessments, management and coordination, partner relationships, landowner relations, public outreach, funding, and project selection and design criteria. Results from the interviews were synthesized with complementary information from TU reports and relevant watershed management literature.

Results and Discussion

In 1998, this author co-wrote a paper synthesizing lessons learned based on her experience managing the Kickapoo project, TU's second Home Rivers Initiative project (Hewitt and Born 1998). In recent years, there have been a number of broader analyses and collections of case studies aimed at synthesizing and characterizing the common experiences from collaborative watershed restoration projects (Born and Genskow 2001; CSPWS 1998; Huntington and Sommarstrom 2000; USDA Forest Service 2003; Williams et al. 1997). There were many similarities in the findings among these studies, which have been further corroborated by the recent interviews with TU's Watershed Programs staff.

There were several major areas of agreement between TU's experience catalyzing watershed projects, and other watershed initiatives that have been similarly evaluated. High quality assessments and strong scientific underpinnings for restoration techniques are invaluable in guiding and executing conservation plans. They help ensure that scarce resources are used most effectively (Hewitt and Born 1998).

Given a site with good conservation potential, all TU's project managers agreed without exception, that good partnerships and effective coordination are the most important aspect for successful watershed restoration projects. This is echoed strongly in a number of the other studies (Born and Sonzogni 1995; Born and Genskow 2001; Hewitt and Born 1998; Sommarstrom 2000; USDA Forest Service 2003). The role of the project manager is central to cultivating partners, coordinating activities, leading outreach efforts, and resolving inevitable conflicts. Successful coordinators have excellent people skills, an ability to understand the relevant technical issues, good organizational skills, and are able to maintain both a sense of the "big picture" and all of the moving parts (Sommarstrom 2000).

Finally, stable and adequate funding is necessary to maintain the viability of watershed restoration efforts. It is reasonably easy to find funding for the on-the-ground restoration work for good projects. However, securing sufficient resources to support the work that is necessary to plan and implement good projects - such as staff and organizational support, engineering and scoping plans, or research and monitoring - is often much more challenging (Huntington and Sommarstrom 2000).

As a national level nongovernmental organization convening locally based watershed projects, TU holds a unique position. TU has the existing network to garner resources that might not be available to local organizations, and the benefit of experience coordinating numerous other watershed projects. TU's stature as a national organization can also increase the level of awareness and credibility among the local community relative to ongoing conservation and restoration activities (Genskow 1999). However, TU does not initiate these projects with the intention of remaining in the watershed indefinitely. A central element of TU's watershed model is to help develop the management tools and organizations to carry on the work into the future, without the ongoing presence of TU. TU aims to remain in a watershed for three to five years, but will occasionally stay longer if funding and work permit. This presents the additional challenge of developing and executing a sensitive exit strategy from projects. We are unable to adequately evaluate this particular aspect, as TU is still active in most of its project sites.

What is abundantly clear both from TU's and others work is that even though science plays an extremely important role, working successfully with partners, landowners, and the local community is critical to the success of these efforts. In addition to these major themes, the interviews with TU's watershed project managers yielded a rich level of detail worth sharing with a broader audience.

Role of Science and Assessments

As evident in Table 1, TU's watershed work spans a wide array of restoration issues. TU projects have served as laboratories for innovative science and restoration work, such as using aerial remote sensing to detect acid mine drainage, using temporary ditch liners to improve irrigation efficiency, and monitoring native species restoration projects. It is obviously important to have the scientific assessments and analysis to determine what the underlying stressors are to a system, and how to address them. Where assessments have not been done, their absence has been felt and TU frequently moves to fill the void. The assessments and reports serve others purposes as well. They are useful when approaching partners, landowners, and potential funders to help develop buy-in and secure resources and commitment. In cases where TU initiated assessments, those reports established TU as a local expert, generally increasing our credibility.

Partners

TU recognizes the tremendous importance of developing and maintaining good partner relationships and, in particular, the vital role of natural resource agencies (Born and Genskow 2001). However, this was a lesson hard learned through our first Home Rivers project on the Beaverkill. In that case, TU failed to consult sufficiently the natural resource agencies or other potential partners before project initiation, and announced the project through an aggressive media campaign that proclaimed the impending demise of the river and the failure of agency managers to act on its behalf. TU repeatedly overstated it own role and underplayed that of other organizations. Unsurprisingly, TU alienated some very important partners which significantly impeded progress for many years (Conyingham and McGurrin 1997). TU quickly learned to mend its ways and currently we enjoy excellent relationships on most projects. Partners are often grateful for the roles that TU plays in these efforts including seeking out additional funds, public outreach, acting as a bridge among various groups and interests, and serving as a catalyst in recognizing problems and implementing solutions.

Productive partnerships share common characteristics as do unproductive ones (Table 2). In the best circumstances, good partnerships also have the ability to broaden the scope of a project. Unproductive partnerships can slow progress or even defuse projects. In the worst cases, a single defiant person in the right position can doom an entire project. TU persisted in the Beaverkill and eventually developed some excellent working relationships with partners, but in other cases we simply pulled out of potential projects when the intransigence of prospective partners grew to be overwhelming. We have experience on a few projects where changes in key staff positions have helped previously stalled projects move forward. Other evaluations have found that successful watershed projects tend to occur where there is already high local civic capacity, where individuals and organizations have constructive networks and communication (USDA Forest Service 2003). For instance, both the Kickapoo and Jefferson River projects benefits greatly from a positive history of cooperation among agencies or the existence of a functional watershed council.

Table 2. Characteristics of Productive and Unproductive Watershed Project Partnerships

Productive Partnerships	Unproductive Partnerships
Common values and vision of problems and solutions	Territoriality of management turf or scientific data
Mutual benefits shared in outcomes	Personality clashes
Positive interpersonal relationships	Enforced cooperation through regulatory action
Investments of time, expertise, and resources	Lack of champions of sufficient status within an organization to commit resources
Proactive attitudes	Interested solely in partner funding, not in working collaboratively
Effectiveness within own organizations	
Willingness to share credit	

Management and Coordination

Coordination is the key element to making integrated watershed conservation projects operational and successful. Facilitating the exchange of information and resources and addressing the inescapable conflicts provide the fuel for moving a project forward. It should never be treated as an afterthought (Born and Sonzogni 1995; Sommarstrom 2000). In this light, the role of a coordinator is clearly essential. The downside is that effective coordination can be extremely time consuming. The challenge for TU is to not become overburdened by process, but to provide sufficient opportunities and structure for interaction and communication to maintain the relationships, trust, and momentum.

TU's watershed model allows for flexibility in management and coordination arrangements. Project management arrangements range from the formal, to ad hoc. The more formal arrangements have an established body, such as a watershed council or an advisory committee that meets on a regular basis. Regular interaction and communication among the partners helps build strong relationships and increases visibility, credibility, and trust. Less formal arrangements have a regular partner group that may meet annually or semiannually. Ad hoc arrangements have various combinations of partners that meet as needed on a project-by-project basis. Ad hoc and less formal arrangements work well when there are a small number of partners and relatively discrete work objectives.

Landowners

In watersheds dominated by private lands, working cooperatively with landowners is another critical factor to project success. TU projects, like other watershed initiatives, have experienced a number of instances where lower priority conservation sites are restored because project initiators were unable to get landowner cooperation on more strategic sites (Sommarstrom 2000). Working in a watershed large enough to provide numerous private landowner opportunities is helpful to avoid being held “captive” by uncooperative parties in particular site or subwatershed.

In one sense, landowners are just another partner group, but they bring unique concerns to the table. In many rural areas local landowners are suspicious of both outsiders and government agencies. Hiring a project manager with local ties can ease relations with the local community. In our experience, some landowners prefer working with TU rather than government agencies, thus we serve as an important liaison. Knowledge or awareness of the successes and failures of past projects can have a huge influence on how well disposed landowners are to cooperating. Landowners (and partners and funders) like to be involved with successful projects.

A number of our project managers experience certain regulatory issues that affect landowners. In projects where the goal is to restore populations of an endangered species, landowners may be reluctant to cooperate for fear of limitations associated with the Endangered Species Act. Across the West, water rights are paramount. In addition, in the case of attempting to clean up abandoned hard rock mining waste, the ability to become exempt from federal liability under CERCLA for abandoned mine clean up is of overriding concern to landowners.

Finally, on working landscapes, asking for landowner cooperation could mean asking them to take a risk with their livelihoods. Project managers have learned to take enough time to build a trusting relationship with these landowners, keep them well informed, and always follow through on commitments. Especially when dealing with financial or legal access issues it is also a good idea to get things in writing. Providing creative incentives that could also help them improve their own operations, such as irrigation improvements, has proven to be a compelling enticement to cooperate.

Outreach

Outreach is the vehicle for keeping partners, landowners, and the local community informed about project activities. The standard tools that describe the project and its outputs, such as brochures, newsletters, reports, press releases, web sites, presentations, and interpretive signs are all used to varying degrees by the individual projects. Many project managers interviewed for this study rightly emphasized the worth of “face time” in local community establishments and kitchens to help build relationships and awareness. All the managers recognized its importance, but most expressed a desire or need to do more. As one manager aptly noted, “You need to get information out to the local community regularly, or they assume you are up to no good.” Ideally, education and engagement can help overcome disinterest and even distrust of restoration activities, although some project managers have been surprised by the limited role that education and awareness alone can play in changing attitudes and behaviors (Wood et al. 1997).

Funding

Funding, a critical element to project viability, is not unlike landowner or partner cooperation. Proven success often leads to additional funding flowing more easily to project. However, many project managers identified locating sufficient matching grant funds as a significant issue for their projects. Most of the projects have grants from federal sources, which require equal or greater levels of nonfederal match. This can be difficult to find, particularly in the West where there is an abundance of federal money, but nonfederal match is extremely scarce. In some cases, we have had to leave money on the table for lack of matching funds. In other cases, we have identified lack of government funding as a major impediment to project progress. In the case of abandoned mine remediation in the West, there are virtually no federal government programs to help fund clean ups on private lands, and it is even limited for clean ups on public lands.

Project Selection and Initiation

Since the first project on the Beaverkill, TU's approach to selecting and initiating projects has evolved. The primary criteria that we use are conservation benefit, the presence of willing and capable partners, and the availability of adequate funding. When we have allowed outside political pressures to occasionally nudge us into a project, we have struggled because of the lack of at least one key element. Once projects have been selected, we approach the community and partners more conscientiously, collecting existing information, consulting them about our plans, being careful to share credit and not assign blame. TU learned early that entering an area with a "white knight" attitude towards saving the river and fishery wins few allies. Some project managers expressed a desire to have more project funding lined up at the outset of the project to avoid so much front end time being devoted to fundraising.

Project Scope and Scale

Most project managers found the size and scope of their projects manageable, though acknowledged the heavy time demands required to travel through a large area or coordinate among many partners. Home Rivers sites range from ~200 to 800 square miles. Several managers pointed out that TU does not take a truly comprehensive approach to watershed restoration. TU's strategic focus is on restoring processes that will improve water quality, healthy channel-forming processes, and robust fisheries. TU is less concerned with terrestrial species, except where they influence the river. While this strategic scope allows TU and its partners to focus more effectively on key issues, the fact remains that the projects generally address some comprehensive issues. On the other end of the spectrum, as TU develops experience on certain key issues they are recognizing the need to move up to the next geographic scale in order to effectively address impacts.

Conclusion

Watershed restoration is central to TU's mission, so it is not surprising that we fill this distinctive niche among national conservation organizations. This paper has detailed an impressive range of lessons learned from the array of TU's watershed projects. Many of these are common to the experiences of most other watershed restoration initiatives, other are unique to TU. This kind of reflection on our experiences provides excellent grounding and intelligence about the range of issues one might face as TU and other groups embark on new watershed adventures. However, we must resist the effort to generalize these into a rigid formula for implementing future watershed restoration projects. As our experience illustrates tactics that may work beautifully in one setting may not transfer successfully to another location. The true strength of TU's Watershed

Programs model is its commitment to broad principles, but great flexibility in implementation.

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A Watershed Scale Approach for Conserving Fluvial Bonneville Cutthroat Trout in the Bear River, ID-WY

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ABSTRACT—Bonneville cutthroat trout (BCT) occupy <5% of their historic range and are largely relegated to isolated headwater tributaries. Bear River BCT, however, are unique in that they continue to persist in the mainstem river system in which they evolved, despite habitat degradation and introductions of non-native competitors. These fish exhibit a fluvial life history strategy, traveling large distances to satisfy specific habitat requirements during different life stages—a trait that renders them especially sensitive to habitat fragmentation and presents unique conservation challenges. In 2002 Trout Unlimited partnered with federal and state agencies and local landowners to combine research, public outreach, and on-the-ground habitat restoration to implement a watershed scale BCT conservation program in the upper Bear River drainage. In 2003 we used two way fish traps and electrofishing to document BCT migrations between tributary spawning habitats and mainstem overwintering habitats. We found that (i) large numbers of juvenile BCT migrated out of spawning tributaries during spring, (ii) few adults moved downstream during the summer, and (iii) BCT captured moving downstream did not represent a cross-section of resident populations upstream. We used this information to gain local support for rebuilding existing irrigation barriers to accommodate fish movements during peak migration periods.

Introduction

Bonneville cutthroat trout (BCT) currently occupy <5% of their historic range and the subspecies is designated as 'Sensitive' by the USDA Forest Service and the state of Wyoming, and 'a Species of Concern' by the states of Utah and Idaho. The Thomas Fork, the neighboring Smith's Fork, and sections of the Bear River between these two tributaries support one of the most genetically pure populations of BCT throughout its native range and comprise what is likely the last connected large river habitat available to the subspecies (**Figure 1**). Independent research projects were initiated in 1998 and 1999 by the University of Wyoming and Utah State University, respectively, with the goal of gaining a better understanding of the life history characteristics, habitat requirements, and movement patterns of BCT within the Thomas Fork and Bear River. These studies showed that BCT in this system exhibited a fluvial life history strategy, using habitats in lower elevation, mainstem rivers for growth and maintenance and migrating large distances (up to 90 km) to headwater habitats to spawn. This research also indicated that three full-spanning diversion structures on the Thomas Fork block access to upstream spawning habitats and entrain downstream migrants in irrigation canals (Colyer 2002, Schrank 2002).

These studies and others like them suggest that past efforts to protect native cutthroat trout subspecies through isolation (Stuber et al. 1988, Moyle and Sato 1991, Young 1995) may have come at the expense of localized life history adaptations and genetic diversity. In addition to habitat and space limitations that might render isolated tributary populations especially vulnerable to extinction

(Dunning et al. 1992, Hilderbrand and Kershner 2000, Harig and Fausch 2002, Novinger and Rahel 2003), these ‘conservation by isolation’ techniques also select against migratory life histories and can lead to genetic and behavioral changes within the isolated population (Northcote et al. 1970, Northcote 1992, Young 1996). As a result, reestablishing watershed connectivity is now the preferred conservation tool in many systems.

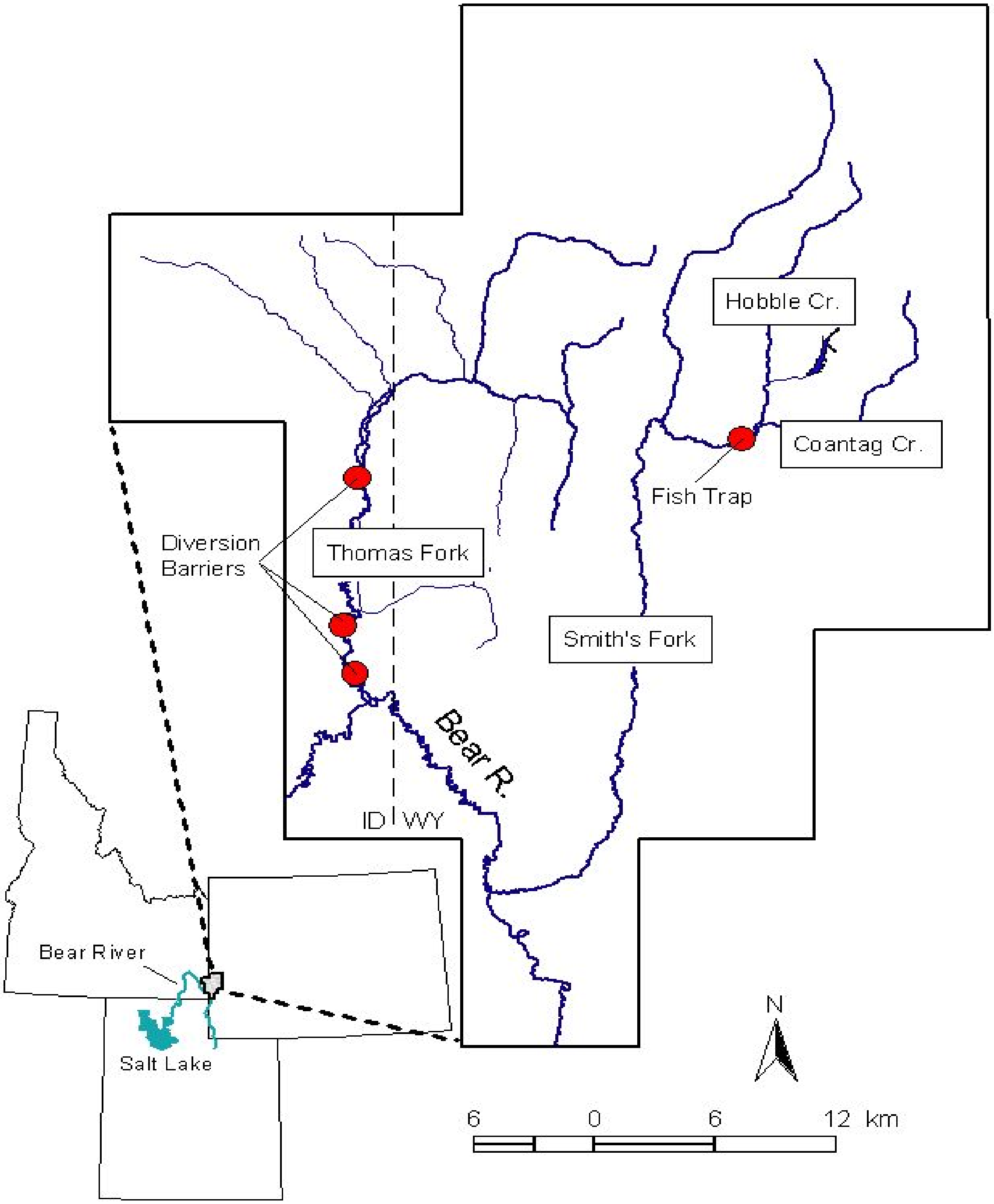

Figure 1. Upper Bear River watershed project area showing Thomas Fork diversion barriers and Hobble Creek fish trapping site.

The Thomas Fork—Smith's Fork—Bear River network constitutes what is likely the last mainstem river habitat available to fluvial BCT and provides a unique opportunity for this type of large-scale watershed reconnection project. In 2002 Trout Unlimited partnered with the US Forest Service, the US Fish and Wildlife Service, Idaho Department of Fish and Game, Faucet Irrigation Co., and several private landowners in the Thomas Fork Valley in southeastern Idaho to begin retrofitting the three full-spanning irrigation diversion structures in the Thomas Fork with fish screens and fish bypass channels. Fluvial BCT in this system face a two-fold challenge during their migrations between mainstem and spawning habitats. During dry years adults in the mainstems of the Thomas Fork and Bear River are prevented from accessing spawning habitats in the upper Thomas Fork and its tributaries by full spanning irrigation diversions along the lower Thomas Fork (Colyer 2002). During wet years irrigation activities begin late enough to allow upstream migration of fish past irrigation diversions, but nearly 50% of those fish subsequently die in unscreened irrigation ditches during their post-spawn return to mainstem habitats (Schrank 2002, Thomas Fork landowners, pers. comm.). Current research suggests that adult BCT moving downstream in the Smith's Fork suffer a similar fate in irrigation canals (J. Roberts, University of Wyoming, pers. comm.). To date, research has focused on adult BCT in the system, and we now have a better understanding of adult fluvial BCT movement patterns and life history requirements. However, we still know very little about the effective size of this population component or about juvenile migration patterns and distributions throughout the system. To that end, Trout Unlimited initiated research in 2003 in the Smith's Fork of the Bear River to gain a better understanding of (i) fluvial BCT population numbers, and (ii) juvenile distributions and outmigration timing in the Bear River and its tributaries. We will use this information to evaluate population recovery in the Thomas Fork following our restoration activities.

Methods

In addition to acting as project lead on habitat restoration and barrier removal efforts in the Thomas Fork, Trout Unlimited is also conducting all follow-up monitoring and evaluation activates associated with the fish passage project. As part of a BACI (before-after-control-impact) study design, we began in June 2003 to monitor downstream BCT movements in Hobble Creek in western Wyoming, a tributary that is known to provide spawning habitat for fluvial migrants from the lower Smith's Fork and the Bear River. We used picket weirs and two way trap boxes to capture fish greater than 100 mm moving upstream and downstream in Hobble Creek. We also conducted three pass depletion electrofishing surveys in 100 m reaches throughout the upper drainage.

Trapping

We monitored upstream and downstream movements in Hobble Creek from June 30, 2003 through September 22, 2003 using a picket weir with upstream and downstream trap boxes. The weir was located approximately 400 m downstream from the confluence of Hobble and Coantag Creeks (4690144 N 517065 E, UTM NAD27, zone 12). All BCT were weighed and measured and those >130 mm total length were anesthetized with clove oil (30 mg/L; Prince and Powell 2000) and implanted with Passive Integrated Transponder (P.I.T.) tags (Biomark, Inc., Boise, ID). We implanted all BCT >200 mm with Visible

Implant (V.I.) tags (Northwest Marine Technology, Shaw Island, WA) in addition to the P.I.T. tags. All captured brown trout (BNT) were measured, and BCT and BNT captured prior to August 1 were given adipose clips. On August 1 we began to clip the right maxillary of all captured BCT in order to differentiate between fish that we had clipped and the adipose clipped fish that were released into the Smith's Fork in July by WYG&F. We counted and recorded the direction of movement for all other fish species that we captured. Following handling, all fish were released either upstream or downstream of the trap depending on their direction of travel.

Population Surveys

We conducted electrofishing surveys upstream from the weir location site in both Hobble and Coantag Creeks. We established 100 m survey sites at 1 km intervals moving upstream from the trap, and used block nets with a standard three-pass depletion methodology. We conducted a third pass only if the second pass yielded >20% of the total number of trout captured in the first two passes. We calculated maximum likelihood abundance estimates for BCT captured during surveys using the Zippin estimator within the program CAPTURE (White et al. 1982). All BCT were weighed and measured and tagged according to the same size criteria used for weir captures. All BNT were measured and numbers of mountain whitefish (MWF) and sculpins (S) were recorded.

Angling

We periodically angled for BCT and tagged captured fish with P.I.T. and V.I. tags to document trends in fluvial BCT densities in habitats upstream of our traps and to see whether these fish later moved through our traps. All angled fish were captured with artificial flies tied on single barbless hooks and kept in in-stream live wells for no longer than 15 minutes before processing. All angled BCT were anesthetized, weighed, measured, and tagged according to the protocol previously outlined. All angled BNT were measured and recorded.

Results

Trapping

Between June 30 and September 22 we captured a total of 623 BCT, 133 BNT, 166 sculpins (S), 231 mountain whitefish (MWF), and 3 suckers (not identified to species). Ninety-six percent of captured BCT were moving downstream (595 of 623). Mean total length for captured BCT was 130 mm and ranged from 89 to 480 mm. Length frequency comparisons between BCT captured in weir traps and those captured during electrofishing surveys in Hobble and Coantag Creeks indicated that BCT moving through the weir were not representative of the size classes present in upstream populations. BCT between 90 and 120 mm TL accounted for roughly 67% of all of the BCT captured in our traps, while that size class made up only 18% and 35% of BCT surveyed in Hobble and Coantag Creeks, respectively. BCT capture rates were high at the outset of trapping and declined throughout July and August, suggesting that we installed our weir at or just after the peak of outmigration (Figure 2).

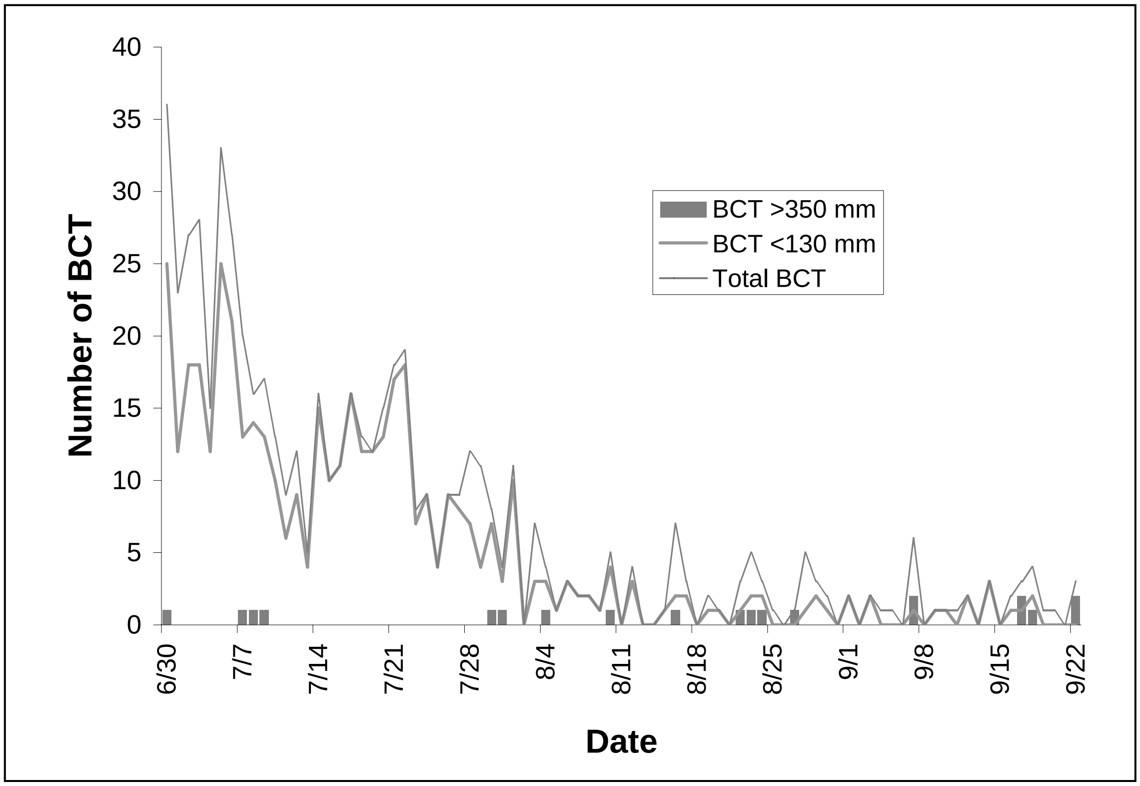

Figure 2. Chart of outmigration numbers and timing for two size classes of BCT. Numbers of juvenile BCT moving downstream through the weir traps were greatest during July and decreased throughout the summer. In contrast, the few large adult BCT that were captured in our traps moved throughout the study period in no obvious pattern.

Population Surveys

We surveyed 13 sites in Hobble Creek between July 23 - 27 and captured a total of 96 BCT, 38 BNT, and 681 S. We tagged 47 BCT with P.I.T. tags and 25 with V.I. tags. We had 6 mortalities, all of which appeared to be due to electrofishing injuries. Abundance estimates ranged from 4 to 19 BCT per 100 m reach and mean total length ranged from 105 to 308 mm across sample sites, indicating a non-uniform distribution of size classes among sites. We surveyed 8 sites in Coantag Creek between August 18 - 21 and captured 97 BCT, 5 BNT, 1 MWF, and 613 S. We tagged 33 BCT with P.I.T. tags and 16 with V.I. tags. We had 5 mortalities that were probably due to injuries incurred during electrofishing. Abundance estimates in Coantag Creek ranged from 5 to 26 BCT per 100 m reach. Mean total length ranged from 91 to 204 mm, again indicating a non-uniform distribution of age classes among our sample sites (Table 1).

Angling

We captured 15 BCT by angling on four different occasions. All angled fish were tagged with P.I.T tags and 11 of the 15 received V.I. tags. Total lengths ranged from 168 to 470 mm. Two of these fish were subsequently recaptured by angling several weeks after they were tagged at or near their initial locations. However, none of the BCT tagged during angling had moved downstream through our weir by the time it was removed at the end of September.

Table 1: Bonneville cutthroat trout (BCT) abundance and size data from three-pass depletion electrofishing on 100 m reaches in Hobble and Coantag Creeks in July and August 2003. *N* = population estimate, *p* = capture probability, SE = standard error, and CI = confidence interval.

	No. of BCT Pass			BCT Abundance				Total Length (mm)		Weight (g)	
Reach	**1**	**2**	**3**	***p***	***N***	**SE**	**95% CI**	**Mean**	**SE**	**Mean**	**SE**
				Hobble Creek--July 23-27, 2003							
1[1]	5							307.6	54.0		
2[1]	4							215.0	53.8	170.7	88.6
3[1]	6							286.2	42.7	439.1[3]	159.5
4	16	3		0.86	19	0.8	19-19	125.6	13.6	38.3[4]	14.5
5	6	1		0.87	7	0.4	7-7	145.7	17.9	42.5	13.1
6	3	0			3[2]			104.7	12.8	11.9	4.4
7	2	2	1	0.56	5	1.2	5-5	124.2	22.9	33.6	19.4
8	7	1		0.89	8	0.4	8-8	126.6	27.5	47.5	34.4
9	3	1	0	0.80	4	0.2	4-4	106.5	17.7	16.8	9.0
10	8	4	2	0.61	14	1.5	14-24	116.9	15.7	35.0[5]	13.2
11	4	2	2	0.52	9	1.9	9-20	166.3	27.2	75.1	29.1
12	3	1	0	0.80	4	0.2	4-4	152.8	15.5	45.0	12.6
13	6	2	1	0.70	9	0.7	9-9	193.8	24.8	105.4	31.8
				Coantag Creek—August 18-21, 2003							
14	6	5	2	0.50	14	2.8	14-29	146.5	16.0	52.0	17.7
15	6	1		0.87	7	0.4	7-7	133.7	27.8	52.4	31.9
16	14	9	2	0.60	26	2	26-36	108.2	7.7	21.6	10.1
17	4	1		0.83	5	0.5	5-5	90.6	6.2	7.6	2.0
18	8	1		0.90	9	0.4	9-9	203.2	24.9	131.6	38.3
19[6]	8	4	3	0.51	17	2.8	16-31	146.5	28.5	122.2	73.7
20	8	4	1	0.68	13	0.9	13-13	204.4	31.7	215.2	101.8
21	7	2	1	0.71	10	0.6	10-10	138.5	15.6	40.8	13.0

[1] *Stream flow prevented the use of block nets so we did not attempt depletion sampling but instead made only one pass.*

[2] *Capture probability and a reliable population estimate could not be calculated when BCT were not captured on the second pass so the number of captures was reported without confidence intervals for this reach.*

[3] *Mean weight was calculated from only 5 BCT because one BCT was not weighed accurately (TL = 126).*

[4] *Mean weight was calculated from only 18 BCT because one BCT was not weighed accurately (TL = 76).*

[5] *Mean weight was calculated from only 13 BCT because one BCT was not weighed accurately (TL = 67)*

[6] ***One BCT escapee (TL ~ 110) was included in pass totals but not measured or weighed.***

Discussion

Our trapping and electrofishing results indicate that: (i) large numbers of juvenile BCT between 90-120 mm TL migrated out of Hobble Creek during spring run-off, (ii) few large adults moved downstream during the summer, and (iii) BCT that moved downstream through our weir did not represent a cross-section of resident populations upstream.

Hobble Creek is thought to provide spawning habitat for fluvial Bear River BCT (Colyer 2002) and we suspect that these outmigrants are fluvial offspring. Juveniles were captured in surprisingly high numbers (i.e. 25-30 individuals per day) at the outset of trapping, but those numbers declined throughout July and August, suggesting that we installed our weir sometime at or just after the peak of juvenile outmigration. If we assume that outmigration numbers follow a somewhat normal distribution, then we can conclude that many of these fish were probably outmigrating during June, as well. Our trap boxes were able to reliably retain only BCT that were greater than 100 mm in length, so we cannot say whether YOY were outmigrating during this time. At the outset of this study we expected that fluvial BCT offspring probably remained in tributaries for 2-3 years until they attained greater sizes, at which point they would start to gradually move downstream. In fact, sixty-seven percent of BCT that we captured were probably age 2 fish (90-120 mm TL; otolith analysis pending), suggesting that many juvenile BCT appear to remain in spawning tributaries for only one full year after they emerge before moving downstream.

Recent studies have significantly improved our understanding of the life history requirements, seasonal distributions, habitat preferences, and migration patterns of fluvial BCT in the Bear River (Schrank 2002, Schrank et al. 2002, Colyer 2002, Burnett 2003), but we still know very little about the effective size of this population component. Initially we had hoped to use weirs to estimate the numbers of fluvial adults that were spawning in Hobble Creek without disturbing spawning fish by electrofishing or snorkeling. Based on studies conducted in the neighboring Thomas Fork drainage, we assumed that BCT would be actively spawning between May 15 and June 15 (Colyer 2002, Schrank 2002). However, high streamflows prevented us from installing our weirs prior to June 30, and we caught surprisingly few adult outmigrants after that date.

One possible explanation is that fluvial adults remained in Hobble Creek after they spawned and did not make it downstream to our weir by the time it was removed at the end of September. We captured several large (>400 mm) fish upstream from our weir in Hobble creek during angling and electrofishing surveys in July and August, but none of these tagged fish moved downstream through the weir. We did capture a few untagged adults moving downstream during the last few days of trapping in late September, which suggests the possibility that adults were just beginning to move when we removed our weirs. However, a more likely explanation is that many of the fluvial spawners had already left Hobble Creek by the time we installed our weir. Schrank (2002) found that only 20% of tagged post-spawn adult BCT in the Thomas Fork remained in the tributaries in which they had spawned. Similarly, anecdotal evidence suggests that large numbers of adult spawners use a fairly discrete section of Hobble Creek for spawning, but then begin to move downstream soon afterwards (H. Berge, USDA Forest Service volunteer, pers. comm.). Researchers in the lower Thomas Fork and the Bear River found that radio tagged BCT that overwintered in these mainstem reaches disappeared in the spring and then reappeared at the beginning of the fall. A few of these fish were successfully tracked to upstream locations in Hobble Creek during May and June prior to transmitter failure (Colyer et al. in prep).

Juvenile BCT ranging in size from 90 to 120 mm accounted for 67% of all weir captures, but that size class made up only 35% and 18% of our survey populations in Coantag and Hobble Creeks, respectively. Electrofishing surveys further indicated that juvenile fish were not evenly distributed throughout the two streams but were concentrated at specific sites. In Coantag and Hobble Creeks we found that juveniles dominated our samples at only one site in each stream. Survey reach 16 in Coantag Creek had a population estimate of 26 fish, with all but one of them ranging in size between 77 and 132 mm TL. Similarly, reach 4 in Hobble Creek had a population estimate of 19, with 14 of those ranging in size between 72 and 131 mm TL. This concentration of age 1 BCT these sites may suggest that fluvial spawning activity occurs nearby. This hypothesis is corroborated by anecdotal evidence that spawning BCT return each year to spawn in the same sections of Coantag and Hobble Creeks (H. Berge, USDA Forest Service volunteer, pers. comm.), so we intend to test this hypothesis in the future.

Conservation Implications

Telemetry studies in 1998-1999 showed that adult fluvial Bear River Bonneville cutthroat trout used spawning habitats in both the Thomas Fork and the Smith's Fork. Our current study suggests that many of the offspring of these fluvial fish ultimately migrate out of spawning tributaries, thus contributing a major source of individuals to the mainstem Bear River BCT population. Currently, however, drought conditions combined with diversion barriers are preventing BCT from accessing Thomas Fork tributaries, and some of the only spawning habitat now available to BCT is found in the Smith's Fork drainage. Fish have been documented moving out of the Thomas Fork and upstream into the Smith's Fork when the Thomas Fork is not passable (Colyer 2002). Trout Unlimited and the project partners have used this information to gain the support of local landowners and water users for rebuilding the Thomas Fork irrigation diversions to accommodate fish movements. We believe that maintaining open migration corridors between the Bear River and the upper Thomas and Smith's Forks is critical to ensure the long-term persistence of BCT populations in the Bear River system.

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A Large-scale Risk Assessment of the Biotic Integrity of Native Brook Trout Watersheds

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ABSTRACT—Many physical, chemical and biological watershed level changes over the last hundred years have threatened the long-term integrity of native brook trout (*Salvelinus fontinalis*) in the eastern United States. Evaluations of the integrity of native brook trout watersheds over their native range are useful to guide decision makers, managers and publics in setting priorities for watershed level restoration, inventory and monitoring programs. Our objective was to 1) develop meaningful physical, chemical and biological metrics that could be used in watershed level risk, and prioritization assessments and 2) determine the current range of conditions for each watershed level metric to establish a benchmark to assist managers in evaluating the relative conditions of their watersheds at various scales of interest. We screened over 100 metrics and developed a multi-metric risk model (Watershed Integrity Rating—WIR) using metrics that related to watershed and water corridor; land use, sedimentation, fragmentation, air quality and human population. We tested the Watershed Integrity Rating on all 5th level watersheds in the eastern United States that contained National Forest (NFS) lands and native brook trout (current and historic). Watersheds in the Western Great Lakes region had the highest Watershed Integrity ratings while New England and the Southern Appalachians had the lowest ratings. Many individual watersheds throughout the native range appear to be at risk for brook trout survival with a high percentage of these found in the Southern Appalachians and New England.

Introduction

Many physical, chemical, and biological watershed level changes over the last hundred years (Marschall and Crowder 1996; Galbreath et al. 2001) have threatened the long-term integrity of native brook trout (*Salvelinus fontinalis*) in their historic range in the eastern United States. Evaluations of the integrity of native brook trout watersheds over their native range are useful to guide decision makers, managers, and publics in setting priorities for watershed level restoration, inventory and monitoring programs. Large-scale assessments for many aquatic species have been useful in identifying and quantifying: problems, information gaps, restoration priorities and funding needs (Williams et al. 1993; Davis and Simon 1995; Frissell and Bayles 1996; Warren et al. 1997; Master et al. 1998; McDougal et al. 2001). We developed a multi-metric Watershed Integrity Rating (WIR) that uses whole watershed (Moyle and Randle 1998) and water corridor variables for metrics instead of site-specific variables. Multi-metric indices can assist mangers in their evaluations of watershed health by giving an indicator of overall health when many anthropogenic factors may be contributing to a problem and by assisting in identifying key limiting factors (Barbour et al. 1999; McCormick et al. 2001). Our objective was to: 1) develop meaningful physical, chemical and biological metrics that could be used in watershed level and prioritization assessments; 2) determine the current range of conditions for each metric to establish a benchmark to assist managers in evaluating the relative conditions of their watersheds at various scales of interest; and 3) test the utility of the WIR for setting restoration priorities on National Forest lands that contain native brook trout (current and historic).

Methods

We used 5th level Hydrologic Unit (HU) watersheds (mean size 452 km^2 $\pm$SD 248) for this assessment (Seaber et al. 1987; EPA 2002; USGS 2002b). The 5th level HU was chosen because: 1) it was the smallest size where data was currently available, 2) it is a level of great interest for land management, and 3) it is a size where plans can be developed for conservation management at a reasonable scale (Moyle and Yoshiyama 1994; Master et al. 1998). The watersheds (n = 344) in our study represent all watersheds that contained National Forest lands within the native distribution of brook trout (McCrimmon and Campell 1969; Behnke 2002). We artificially grouped the watersheds for statistical analysis into: Western Great Lakes (WGL), Eastern Great Lakes (EGL), New England (NE), Northern Southern Appalachians (NSA) and Southern Appalachians (SA) (Figure 1). If an ANOVA on the watershed groups was significant, a Tukey HSD multiple comparisons test was conducted (Sokal and Rohlf 2003). The range of the southern Appalachian strain of brook trout delineated the SA region.

The water corridor was 100 m on both sides of all streams and lakes within the watershed. The National Hydrography Dataset (NHD) (1:100,000) layers were used for streams and lakes (USGS 1994). Data on roads was developed using improved Topological Integrated Geographic Encoding and Referencing system (TIGER) data (Navtech 2001). These databases were analyzed using GIS programs that divided the National Hydrography Dataset (NHD) stream layer into gradient segments (Kendal Cikanek, Superior National Forest, personal communication). The spatial data from the 30m National Elevation Dataset (NED)(USGS 2004), 5th level HU coverage, the gradient divided NHD, human census data and the roads data were analyzed to compute metrics related to watersheds, streams, gradient, and roads. Output data included area in the watershed (total, land, and lake), stream/road crossings (total, per stream, by gradient), and road density (total, by distance from stream, by gradient).

We screened over 100 candidate metrics (Whalen 2004) for 1) completeness, 2) redundancy, 3) range, 4) variability, and 5) responsiveness (Hughes et al. 1998; McCormick et al. 2001). All candidate metrics were required to have the same data resolution and definitions for all watersheds and were obtained and/or developed as a Geographic Information System (GIS) to allow for data analysis in a spatial context (Lo and Yueng 2002). Many potential databases (metrics) were eliminated from consideration because they were not available for all watersheds at the same or a suitable resolution. No direct biological metrics met the criteria. The final multi-metric index Watershed Integrity Rating (WIR) consists of five-impact categories sedimentation, fragmentation, land use, human population and air quality each with an associated indicator or surrogate for the watershed and the water corridor within that watershed (Table 1).

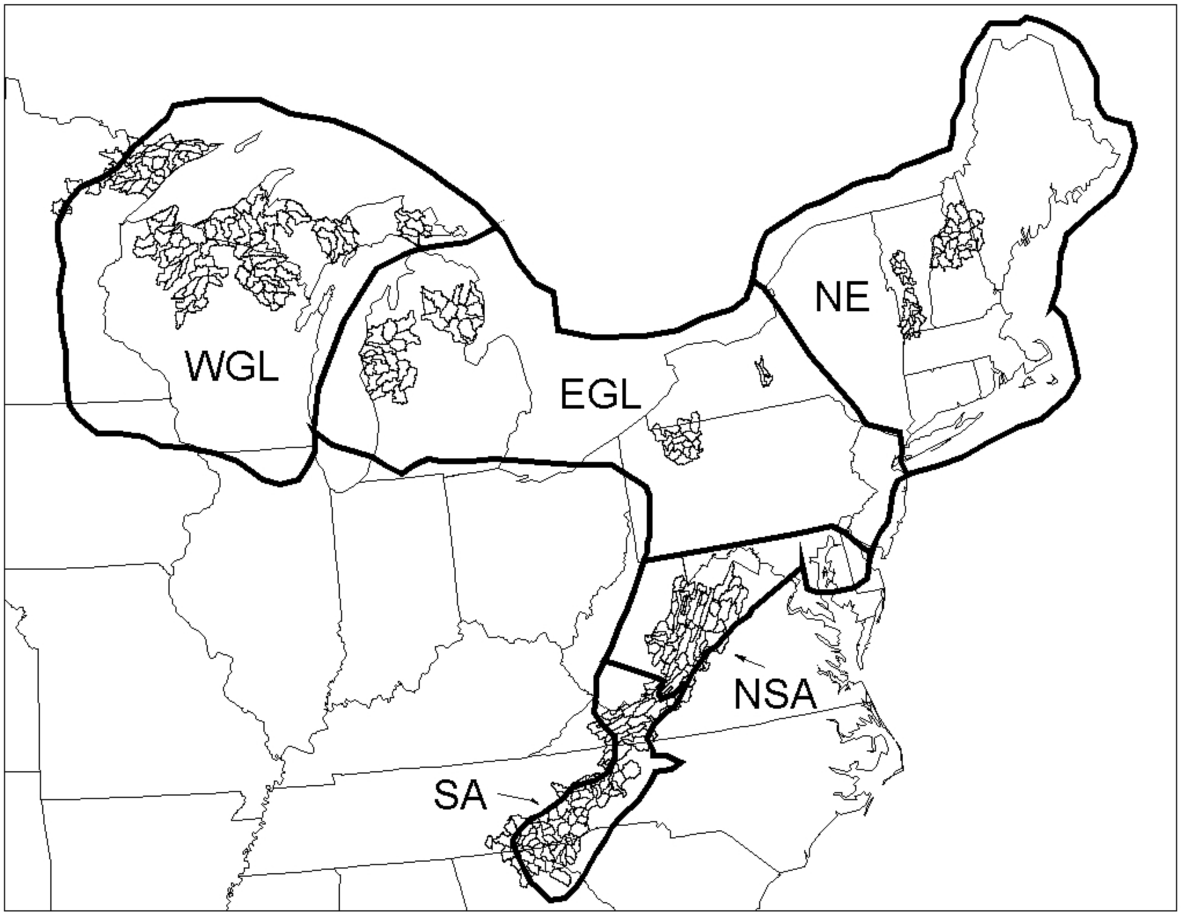

Figure 1. Historic range of brook trout in the eastern United States divided into five watershed groups; Western Great Lakes (WGL), Eastern Great Lakes (EGL), New England (NE), Northern Southern Appalachians (NSA) and Southern Appalachians (SA). The small polygons are 5th level hydrologic unit watersheds with National Forest lands within the native brook trout range.

Table 1. Final watershed and water corridor metrics used in the Watershed Integrity Rating and the mean and range of values. Water corridor is 100m either side of all streams and lakes. Each of the 10 indicators is worth 0-10 points. **Air quality score for the watershed indicator is scored 0-5 points for NO_3 deposition and 0-5 points SO_4 deposition. **Human score for watershed is scored 0-5 points for human population density in 2000 and 0-5 points for growth rate.

Impact	Watershed indicators (10 points each)*	Median (range)	Water corridor indicators (10 points each)	Median (range)
Sedimentation (20 points)	Road density (km/km^2)	1.23 (0.01 —4.89)	Road density (km/km^2)	1.53 (0.00-10.00)
Fragmentation (20 points)	# Dams/km^2	0.01 (0.00—0.11	# Road crossings/stream km	0.42 (0.00-2.08)
Land use (20 points)	% Land with human uses	8.53 (0.31 —79.81)	% Land with human uses	3.66 (0.24-30.51)
Human (20 points)	Population/km^2 Growth rate (1790-2000)	10 (0-281) 12 (1-25)	% Land with residential use	0.25 (0.00-14.30)
Air quality (20 points)	NO_3 deposition SO_4 deposition (kg/ha)	11 (9-18) 14 (7-21)	% Soils in water corridor with buffering capacity pH < 5.0	3.87 (0.00-100.00)

The range of conditions for each indicator metric was determined for all watersheds or water corridors then a percentile score was assigned for each indicator (Davis and Simon 1995; Barbour et al. 1999; Klemm et al. 2002). A scoring system is needed for standardization in the final risk assessment. The WIR scored all ten metrics on the same scoring range (0-10) based on the range of values for that indicator on all watersheds. Metrics were given a score based on the percentile in which they were found, for example if a watershed was in the 83 percentile for a particular metric it would get a score of 8.3. The final score was a summation of the ten metrics for a total range of scores from 0-100.

Final Metrics (Indicators)

Sedimentation was indicated by the surrogate road density (km of road per km^2 of watershed) at the watershed level and by road density within the water corridor (Whalen 2004). Fragmentation at the watershed level was indicated by the number of dams per km^2 of watershed and was calculated from the National Inventory of Dams (NID) (United States Army Corps of Engineers 1998). Fragmentation at the water corridor level was indicated by the number of road crossings per kilometer of stream (Whalen 2004). Land use at the watershed level was indicated by the percentage of the watershed classified as human use in the National Land Cover Data (NLCD)(USGS 2002a). The NLCD was produced using satellite imagery data acquired in 30 m grid coverage. Human use includes low and high intensity residential, transitional, orchards/vines, pasture/hay, row crops, small grain crops, urban recreation, quarries/mines/gravel and commercial/industrial/transportation classifications. Land use at the water corridor level was indicated by the percentage of human land uses within the water corridor. Human population at the watershed level was indicated by a combination of the population density in 2000 and the population growth rate of that watershed since 1790 (Geolytics 2001; U.S. Census Bureau 2002; Price 2003; Whalen 2004). The water corridor level metric for human population was the percentage of the corridor that was designated as high or low residential use in the NLCD. Air quality at the watershed level was indicated by the average 1999 nitrate and sulfate deposition (kg/ha) within the watershed (National Atmospheric Deposition Program 2003). Average deposition was based on isopleths that were developed from set sampling points. We used the average nitrate and average sulfate deposition value for each watershed as air quality watershed metric (Whalen 2004). Air quality at the stream corridor level was indicated by the buffering capacity of soils within the corridor (NRCS 2004; PSU 2004) The indicator represents the percentage of soils (upper 10 cm) in the water corridor with a buffering capacity of < 5.0 pH.

Results and Discussion

The mean WIR score was 51 with a range from 14 to 96 (Table 2, Figure 2). The mean scores among the watershed groups were significantly different (ANOVA, df =344, F=130, $p < 0.0001$). The mean scores in all impact indicator categories were also significantly different (ANOVA, df = 344, $p < 0.0001$) among the watershed groups. The indicator values (actual not scored) are summarized (mean and range) in table 1.

Table 2. Mean (± SE) Watershed Integrity Ranking (WIR), and impact scores for the Western Great Lakes (WGL), Eastern Great Lakes (EGL), New England (NE), Northern Southern Appalachians (NSA), Southern Appalachians (SA) and all watersheds (ALL) groups. Means followed by a common letter in a column are not statistically significantly different (ANOVA, p < 0.001; Tukey HSD multiple comparison test)

	WIR	Sedimentation	Fragmentation	Land use	Human	Air quality
WGL	72.5 (1.26) a	14.9 (0.31) a	14.2 (0.35) a	12.8(0.48) a	13.7(0.26) a	16.9 (0.29) a
EGL	48.4 (1.66) b	10.4 (0.52) b	10.9 (0.59) b	7.9 (0.85) b	8.0 (0.48) b	11.2 (0.87) b
NE	36.1 (2.02) c	9.8 (0.55) b	6.9 (0.64) c	7.1 (0.64) b	6.2 (0.41) c	6.1 (0.20) c
NSA	45.8 (1.65) b	9.0 (0.56) b	12.0 (0.61) b	9.1 (0.52) b	8.7 (0.54) b	7.0 (0.44) c
SA	36.4 (1.27) c	4.87 (0.37) c	6.0 (0.39) c	9.5 (0.53) b	5.4 (0.34) c	10.7 (0.33) b
All Watersheds	51.2 (1.06)	10.1 (0.28)	10.4 (0.28)	10.0 (0.29)	9.1 (0.25)	11.7 (0.28)

The WGL watershed group consistently had the highest mean WIR and impact indicator scores (Table 2, Figure 2). The NE and SA watershed groups had the lowest mean WIR scores and the lowest mean indicator scores for sedimentation, fragmentation and human population. Many individual watersheds have been impacted from multi anthropogenic impacts, with a high percentage of these in the NE and SA watershed groups. These watersheds are also some of the most impacted from exotic fish introductions. We were not able to obtain data at the appropriate resolution to incorporate the impacts from exotics on native brook trout. The effects of stocked brook trout and stocked and naturalized rainbow trout and brown trout have greatly affected native brook trout populations in these regions (Larson and Moore 1985; Galbreath et al. 2001). The introductions of exotic cool and warm water species such as smallmouth bass and walleye have also affected native brook trout waters. A metric that can separate out populations of brook trout not impacted by exotics would be useful in future analysis.

This study was designed to identify the integrity of entire 5th level watersheds across the native range of brook trout in the eastern United States. The WIR is a useful starting point for answering questions appropriate to the scale of analysis. An analysis of indicators from impact categories is a second step that can help identify potential limiting factors. While the WIR and impact scores can help decision makers decide which watersheds to focus in and identify potential limiting factors, project specific restoration and conservation projects will need finer scale data and local knowledge to make wise decisions as brook trout streams in need of restoration and protection can be found in any watershed regardless of WIR score. Improvements in the data that allow for an analysis at a scale such as 6th level HU or individual stream reach are necessary to identify these important within watershed restoration or conservation projects. We used best available surrogates for many impacts because direct measurement data was not available across the range of this study. If available, direct measurement data should be used for restoration decisions.

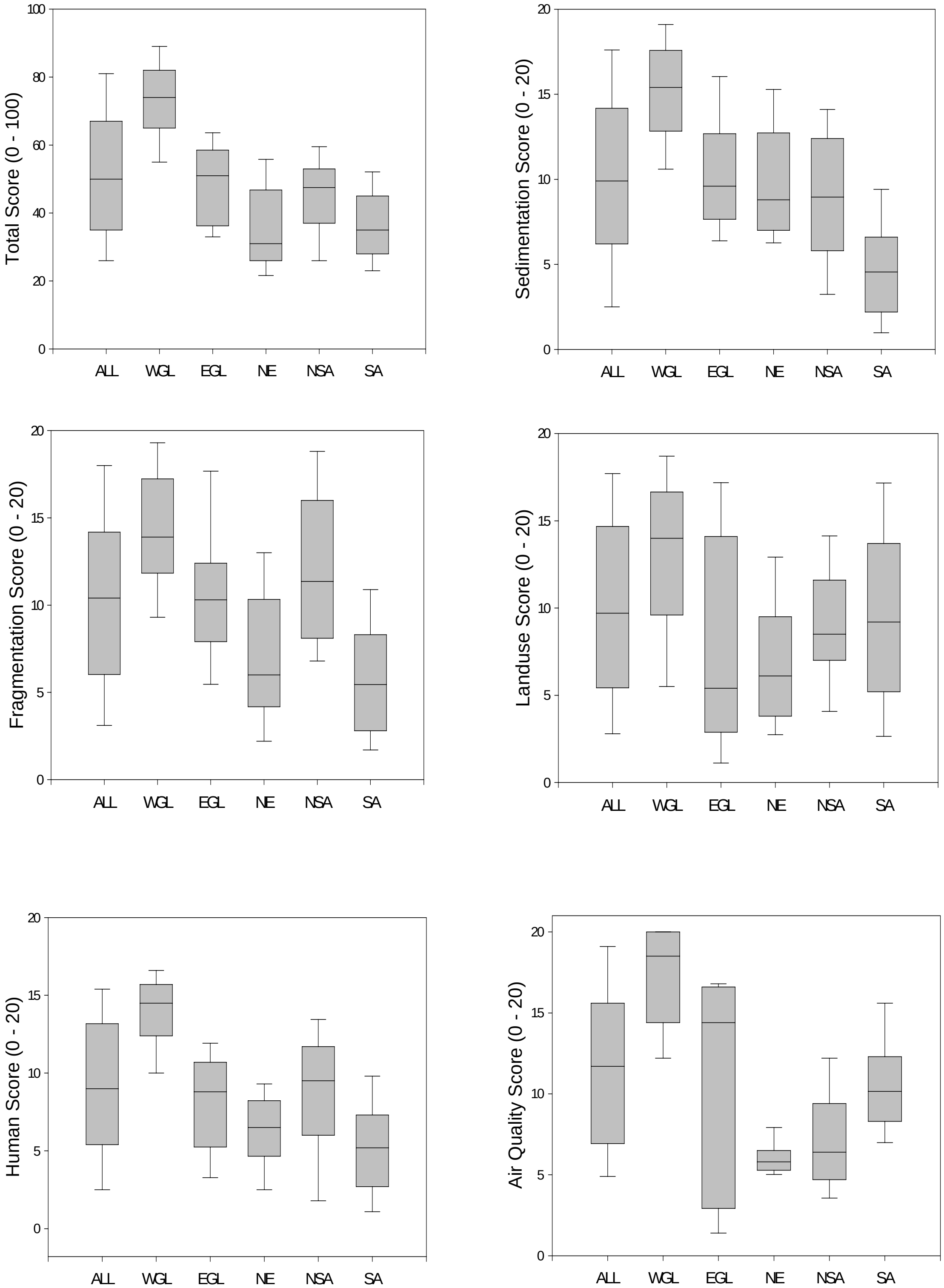

Figure 2. Range of conditions for the Watershed Integrity Rating (WIR) (total score) and individual impact indicators (sedimentation, fragmentation, land use, human population, air quality) for all watersheds (ALL), Western Great Lakes (WGL), Eastern Great Lakes (EGL), New England (NE), Northern Southern Appalachians (NSA) and Southern Appalachians (SA) watershed groups.

We did not run the analysis with 1:24,000 NHD stream and lake data, because it was not available for every watershed, however we conducted many watershed analyses where we had both 1:100,000 and 1:24:000 NHD data. In most cases, the metric indicator values were different but highly correlated ($r > 0.90$) and the relative rankings of the watersheds were not statistically different using a Spearman Rank Correlation test. There were also only small shifts in a watershed's percentile scores for each indicator. We believe our watershed and watershed group findings will be similar when the analysis can be run with a complete 1:24,000 NHD data set. We also did not conduct the analysis on all the 5th level HU within the brook trout historic range because of data gaps (primarily missing official 5th level watershed boundaries). Our experiences with working with all the National Forest watersheds (n = 991) in the eastern United States instead of a subset of brook trout only watersheds (n = 344) showed the range of conditions for most of the indicator metrics to be similar (Whalen 2004). We believe that watersheds with National Forest lands (average ownership 56%) may have better WIR scores on average than the complete set of brook trout watersheds but the impact indicator scores will show similar trends among the watershed groups. The exception may be the NE scores where watersheds with National Forest lands are few and do not include most of the state of Maine where human population and land use indicators may score higher. An analysis for all watersheds is recommended has soon as the final 5th and 6th level HU become available.

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Reaching the Angling Public: Turning Good Science into Good Policy

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ABSTRACT— If fisheries scientists, biologists and managers are to gain public support for good policies, public knowledge and understanding is crucial. Unfortunately, we're living in a time when good science is often ignored, suppressed or distorted, and few people have the time, inclination or opportunity to learn and understand the truth. To gain support for and help promote responsible policies, Trout Unlimited recently launched a Public Lands Initiative to help inform and rally anglers and hunters to understand and protect public lands, and associated fishing and hunting opportunities. A large part of this effort is to clarify and disseminate scientific knowledge, and provide hunters, anglers and others with information they need to help push for responsible policies on public lands. But we need the help of fisheries scientists, biologists and managers; fisheries professionals need to do a better job at denouncing bad science, promoting good science, and providing us the information we need to demand responsible policies that protect our rivers, streams and fisheries. Starker Leopold put it this way: "Buy a trumpet, not a cubbyhole. The truth is out there. Let good science, flavored with compassion, light our way."

Writer Ann Zwinger once wrote, "If you can entice people to look at a facet of nature, they may get curious. If they get curious, they may attempt to learn something about what they are seeing. If they learn something, that becomes an irrevocable part of their experience. If it becomes part of your experience, it becomes yours in a way that nothing else in the world can. We don't own anything; all we own is our knowledge. If you appreciate it and enjoy it, you're a lot less likely to destroy it."

I would add this: If you come to understand, appreciate, and enjoy something, you're not only less likely to destroy it; you're more likely to fight for its protection. We need more people fighting for protection; we need more people who understand and use good science to support good policies and oppose bad policies. If fisheries scientists, biologists, and managers are to gain public support for good policies, public knowledge and understanding is crucial.

Unfortunately, we're living in a time when good science is often ignored, suppressed or distorted, and few people have the time, inclination or opportunity to learn and understand the truth. This is partly why politicians are so easily able to push for massive development of coalbed methane wells across the west with little, if any, understanding on the impacts to water quality, water quantity and fisheries, and undermine protections for roadless lands despite overwhelming evidence of the importance of these roadless lands to trout, salmon and steelhead.

All of our most threatened and endangered trout and salmon spend some portion of their lifecycle in watersheds on federal lands. More than 50 percent of our nation's healthiest, most prized trout streams originate on public lands. Protecting public lands is critical to the survival and restoration of native trout and salmon. Yet, too often, anglers and hunters support policies that degrade habitat on our public lands and oppose policies that would protect these places. Take the federal roadless rule, for example—the only legal protection for roughly

5.5 million acres of roadless lands in Idaho, lands that contain 87 percent of the state's healthy populations of bull trout; 83 percent of Idaho's healthy populations of westslope cutthroat, and 74 percent of Idaho's current chinook and stealhead habitat. Yet, there seems to be a lack of will among some anglers to protect these roadless lands. Sadly, too many anglers support misguided efforts to eliminate protections for these roadless lands. Collectively, we have failed to convey the importance of these roadless lands to anglers; we have failed to pass on the knowledge and understanding that is crucial for public support.

More than 50 years ago, Aldo Leopold wrote, "The sportsman has no leaders to tell him what is wrong. The sporting press no longer represents sport, it has turned billboard for the gadgeteer. Wildlife administrators are too busy producing something to shoot at to worry much about the cultural value of the shooting."

Today, many outdoor writers, and hook and bullet magazines, have become public relation arms of industry, and too many wildlife administrators are fearful of taking stances on sensitive or controversial topics. Anglers and hunters are often led by the wrong people. We need to change this. We need to do a better job of informing and motivating the public to help us protect what little remains of our wild places, wildlife, and wild trout. This begins with helping the public gain a better understanding of science.

So how do we do it? First, there's the standard advice: if you're a decent writer, or speaker, or both, do everything you can to get the word out. Write for newspapers and magazines, offer to speak to civic groups, Trout Unlimited chapters, National Wildlife Federation affiliates and others. If you're not a good writer, or speaker, or both, develop strong relationships with those who are, and constantly and consistently pitch story ideas. My friend John Ormiston, who is a wildlife biologist on the Bitterroot National Forest, once told me to view the public as an ongoing parade, different folks continually passing by, and hit them with the same message over and over. But the message has to be clear, concise and strong. I once had a job writing and editing NEPA documents for the Forest Service (not the most enjoyable work I've ever done.) A hydrologist sent me a statement that read, "Our research indicates the possibility that over utilization of domestic livestock within some riparian areas may quite possibly be having detrimental impacts on riparian vegetation, streambank stability and water quality." I was tempted to put it more simply: "Cows are screwing up the river." Instead, I rewrote it to say something to the effect of "Overgrazing by cattle could be altering vegetation, contributing to erosion, and harming water quality." The Forest Service changed it back to the original wording. I argued it wasn't clear, a bit ambiguous. My boss responded: "We want it to be unclear and ambiguous."

Among my heroes are the scientists who write well and the writers who write well about science. Aldo Leopold, Olaus Murie, E.O. Wilson, Robert Behnke, David Quamen, Ted Williams, and Ted Kerasote, to name a few. In a well-researched article for Field & Stream about a recent spurge of gas and oil development across the West, Ted Kerasote wrote, "If these energy policies continue, we'll have more rivers without fish and fewer hunting opportunities." Pretty clear and unambiguous.

For lots of reasons, not the least being politics, it's tough to get good, scientific information into the popular press, but particularly the hook and bullet press. Tom Beck, an avid and passionate hunter who also happens to be the chief bear biologist for the state of Colorado, once wrote a strong, science-based essay about the impacts of bear baiting on the health and welfare of bears. He also examined the ethics (or lack thereof) of shooting bears over bait. When word got out, the Wildlife Legislative Fund of America and others rallied hunters to threaten Outdoor Life with a boycott if they ran an "anti-hunting" article written by an "anti-hunter." The pressure worked, the editors resigned, and the article never saw print. It's a catch 22, of sorts; we need to inform the public, but a segment of uniformed public prevents us from informing them. Certainly there are groups such as Trout Unlimited, the Rocky Mountain Elk Foundation, Mule Deer Foundation and National Wildlife Federation that publish good, science-based, thought-provoking essays and articles for anglers and hunters. Some of the bolder magazines, such as Flyfisherman and Fly Rod and Reel also do a good job. Unfortunately, too many magazines, and too many state and federal agencies, shy away from tough, complicated, sensitive issues at the slightest hint of controversy.

So how can we change that? We need to reach the grassroots anglers and hunters. We need to build a larger, stronger, more vocal constituency of citizens who understand and support good policies and programs that protect and enhance our public lands, wildlife and fisheries. For your part, you need to do a better job at explaining why our indigenous trout are important, what the threats are, and what can be done about it. You need clear, concise information that shows people the relevance of your work to their lives. You need be consistent and persistent, develop a good, sound message and deliver it at every opportunity you can. And you need to be bold. "If these policies continue, we'll have fewer places to fish and less hunting opportunity." That's a clear, concise, bold message, relevant to anglers and hunters, and can be backed by good science. If you're not comfortable making such statements, get the information to writers, editors, speakers, and people like me, and we'll help spread the word. We need to be better leaders. I was a Sergeant in the Marine Corps, and my favorite definition of leadership comes from the military: "Influencing people by providing purpose, direction and motivation." If we are to save what little remains of our wild trout, wildlife and wildlands, we need to do a better job at influencing anglers and hunters with a sense of purpose, direction and motivation.

Fifty-eight million Americans hunt and fish. Most tend to be political conservative, are seen as partners with state and federal agencies, and are unaffiliated with any organizations. They could be a powerful force for the protection of our wild fisheries, wildlife and wild places. Trout Unlimited is working to rally such a force.

Recognizing the unparalleled value of public lands habitat to coldwater fisheries, drinking water, and wildlife habitat, and the growing threats these lands face, Trout Unlimited has launched a new Public Lands Initiative to protect remaining pristine fish and wildlife habitat and restore streams and rivers degraded by past mining, energy development, and logging. As part of this program, we are working to: 1) Develop sound scientific and technical information demonstrating the importance of public lands to coldwater fisheries, wildlife and fishing and hunting; 2) Build an alliance of TU members, wildlife and fisheries conservation groups, hunting and angling clubs, and fish and wildlife professionals to advocate for management policies on public lands that protect the long term health of coldwater fisheries as well as wildlife, and; 3) Inform the broader public on how incredibly important public lands are to protecting and restoring coldwater fisheries and wildlife habitat, and the tremendous fishing, hunting and other outdoor opportunities public lands provide.

In other words, we're using science, education, and citizen involvement to influence policy. Thus far, we're focusing our efforts on three areas: abandoned mine reclamation; roadless and wilderness protection; and energy development. My job is to organize anglers and hunters in Montana, Wyoming, Colorado, Utah and New Mexico to support sound, responsible energy policies and development, and oppose bad policies and development. I also speak to a lot of environmental groups. As part of my effort, I am trying to get anglers, hunters and environmentalists to work together more. As writer Ted Williams wrote in an article called "Natural Allies," for Sierra Magazine: "Whenever sportsmen combine with environmentalists, you have 60 to 70 percent of the population, an absolutely irresistible coalition. . . If only hunters, anglers, and environmentalists would stop taking potshots at each other, they would be an invincible force for wildlands protection." Tony Dean, of Tony Dean Outdoors, put it this way, "There is no reason anglers and environmentalists can't agree on most things, especially the importance of clean water."

Trout Unlimited is in a good position to lead this effort. As my boss, Chris Wood, likes to say, "We are the greenest of hook and bullet groups, and the most hook and bullet of the green groups." Simply put, we're helping anglers and hunters better understand the need to protect the places we hunt and fish. In a series of reports we recently produced on energy development, roadless lands and mining—reports that have generated a lot of good national press—we are clarifying and disseminating scientific knowledge, and providing hunters, anglers and others with information they need to help push for responsible policies on public lands. Backed by sound science, we are helping to organize and focus the considerable political clout of anglers and hunters to turn good science into good policy. But we need your help.

If we are to muster support for more responsible public lands policies, we need a better, tighter intersection between science and policy. In other words, we need you to speak out. Help us denounce bad science and promote good science. For our part, we can take that information and demand responsible policies that protect our rivers, streams and fisheries. Starker Leopold put it this way: "Buy a trumpet, not a cubbyhole. The truth is out there. Let good science, flavored with compassion, light our way."

I was invited here to discuss how we can help you disseminate information. I took the task seriously, because it's a serious and important topic. So seriously, in fact, that I came up with an idea on how we can help each other—a way we can gain some attention, help inform the public, and use science to promote good policy. In my efforts to organize anglers and hunters to advocate for more responsible energy policies on public lands, I have written a letter to Secretary of Agriculture Ann Veneman and Secretary of Interior Gale Norton in hopes of creating positive pressure for responsible energy development on our public lands. I am asking each of you here today to sign onto to this letter.

I will read a portion of it to you:

"Dear Secretary Veneman and Secretary Norton:

We, the undersigned fish and wildlife biologists, scientists, professionals, and restoration practitioners, all support the responsible development of our nation's domestic energy resources found within public lands managed by the Bureau of Land Management (BLM) and the Forest Service. At the same time, it is crucial that our nation's leaders recognize the extraordinary value of these lands to fish and wildlife, hunting and fishing, and other wildlife related recreation.

Our public lands sustain some of the cleanest water, healthiest habitats, and finest fishing and hunting in North America. Short-term energy production should never be allowed to diminish the long-term productive capacity of the lands and waters that sustain us all. This is the essence of the BLM and Forest Service's multiple-use mandate.

We urge you to help us develop a more prudent, balanced and conservative energy strategy for our public lands that promotes responsible, environmentally and economically sound development; emphasizes efficient methods of energy use and extraction; and seeks to expand the development of alternative and renewable sources of energy. When gas and oil development does occur, it should be based on sound science that ensures the long-term health of our fish, wildlife, and water resources.

To that end, we endorse the following principles, and urge they be adopted by the BLM and Forest Service.

- Affirm Multiple Use Management of Federal Lands in Leasing Decisions;
- Set Aside Unique and Important Areas;
- Conduct Thorough Analysis of Potential Impacts;
- Take a More Conservative Approach to Leasing;
- Maintain Federal Control and Management Flexibility;
- Revisit Leases Issued without Sufficient Data;
- Evaluate Impacts of Stipulation Waivers;
- Ensure Adequate Financial Resources for Reclamation;
- Increase Federal and State Agency Resources.

Increased exploration for gas and oil in the Rockies can help produce energy resources, but may also have negative effects on fish, wildlife, and water resources. Fisheries and big game, with significant recreational, economic, and biological importance may be among the natural resources affected by oil and gas development in this region. A better scientific understanding of potential impacts of gas and oil development on fisheries, watersheds and wildlife is essential to assist resource managers in making informed decisions for promoting sustainable development, adequately predicting potential- impacts, and avoiding, decreasing or mitigating threats to our natural resources.

Thank you for your attention to our concerns."

There's more detail in the letter. I have copies in the back. Please grab one, read it and either sign onto it today and get it back to me, or, if you'd rather, you can mail it back to me, or email me your permission to be included. My contact information is on the letter. I hope you will take this task as seriously as I did. Please help us help you to promote and use good science to influence good policies. Working together, we can protect what little remains of our wildlife, wild places and wild trout.

Becoming a Better Communicator

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ABSTRACT—Biologists focus on individual projects, working with the animals they manage, and on the day-to-day minutiae of being part of a public agency. They come to the profession wonderfully prepared to conduct surveys, sample fish, assess results, but unprepared to assume the role of program promoter, writer, or lobbyist. I will suggest ways to improve writing and speaking skills; and ways agencies can facilitate a positive atmosphere where biologists and supervisors can improve communication skills, and reduce resource management problems.

Biologists by their very nature focus on individual projects, working with animals and habitats they have been assigned to manage, and on the day-to-day minutiae of being part of a public agency. They come wonderfully prepared from school to conduct surveys, sample fish, assess results, but unprepared to assume the role of program promoter, writer, or resource lobbyist. In other words, they are unprepared to sell their product to the consumers, anglers most affected by proposed management programs.

Mid-level supervisors focus on overseeing staff operations; keeping agency day-to-day minutiae flowing upstream and down; editing products produced by staff; and making sure staff follows all agency rules and regulations. Most, maybe all, are biologists, promoted from the ranks. They are unprepared to provide an atmosphere that allows staff to work actively with constituents or promote projects and management programs. Instead of working with staff to help sell priority programs, they become bottlenecks to the selling process, passing this responsibility to I&E sections.

How do we change this?

Most of my suggestions apply to both biologists and supervisors. But, for sake of clarity, I'm going to address each group separately, provide suggestions on how to improve the abilities of biologists to communicate effectively with constituents, and reduce some of the angst biologists deal with annually.

Biologists

Good communication skills provide the key to moving beyond simply being a biologist. When you graduated with a BS, or MS, or PhDs, and landed your first job, you came wonderfully schooled in biology, statistics, management techniques, mathematics, computer use, but how much training did you receive in popular writing, speaking, designing and making presentations, etc.?

I had three basic communication courses as an undergraduate and two technical writing courses as a graduate student. I wrote a thesis, but that was all.

Although we have greatly improved our education system and our biological knowledge base, we have failed to broaden our education base to include the social aspects of managing resources. This lack of training makes it your responsibility to acquire those skills you lack, after you join an agency and begin your careers.

What are you Lacking?

Writing Skills

Technical writing is easy; the format is set in stone. Plug in your introduction, materials and methods, results, discussion and literature list, then cap it off with an abstract and you are done. And, as taught in technical writing 101, you do this passively, removing all active construction and personality from the discourse. How do I say boring? Other biologists will plow through your reports and publications, but not resource users.

Writing is a learned skill. It is a skill that can be taught though participatory agency education workshops; voluntary writing groups, led by skilled writers within your agencies; by working one-on-one with agency publication editors; or by organizing and attending communication workshops presented by skilled professional communicators from organizations such as the Outdoor Writers Association of America (OWAA), Southeastern Outdoor Press Association (SEOPA), or Northwest Outdoor Writers Association (NOWA).

Biologists can improve writing shills by sharing written material for editing with other biologists. Both biologists benefit from this exchange.

For example, I shared written material with a fellow biologist, who was and is one of the best technical wordsmiths I know. He routinely bled all over my "Sacred Words" with suggested changes, and I'd reciprocate. We knew we didn't have to take the suggestions, but could pick and choose. Not surprisingly, the end product always improved. Not having the pressure of a supervisor suggesting changes, made the whole editing process less stressful.

One caution: participants must leave their egos and feelings outside the workshop or the editing process. Having someone edit your "Sacred Words" can be gut wrenching. You have to develop a thick skin. The end product will always improve and your name will be on it.

Beyond improving writing skills, design projects to get paid to write and publish the results. Most biologists and agencies work under D/J and W/B funding and must submit project designs with objectives and timetables for the project. Writing takes time. Why not include objectives to complete the finial report and publish the results in a professional and popular venue – AFS publications; outdoor magazines; local newspapers; agency publications; even constituent newsletters such as local Trout Unlimited or Federation of Fly Fishers chapters.

I'm not going to attempt to teach you how to write; this you learn by doing, being edited, revising, and ultimately publishing. However, let me provide a few suggestions to improve and help with the writing process.

- Write actively. Active writing is cleaner, shorter, more to the point and much easier to read.
- Add personal antidotes to articles written for the general public. People like to read about people, even you. Statistics bore people to tears.
- Use humorous antidotes. Humor is difficult to write, however, the best humor is self-depicating humor, especially when it helps make your point.
- Seek opportunities to be published. Small newspapers welcome submissions, especially when they are free; newsletters published by FFF, TU, or other conservation organizations welcome submissions; and

fisheries websites are always looking for conservation material. Be proactive.

- Edit your missives ruthlessly. Word processors and computers, make writing and editing much easier, almost fun. They remove the physical component of writing. Editing can continue until you print the final draft, and even then, if a mistake has been made you can change your product and reprint a revised draft.
- Learn how popular writers structure articles. Like technical writing, outdoor writers use a very distinct format. Read outdoor magazines, not for content, but to learn how articles are constructed. Most start with a hook to grab the reader, followed by the article's meat, and then the authors wrap the article up with an ending tying the article back to beginning. The exceptions to this are newspaper articles, where writers present the most important information in the first couple of paragraphs. This journalistic style developed because most newspaper readers only look at headlines and read the first couple of paragraphs.
- Read manuscripts out loud, and, as you read, mark each section where you have to pause. You will find those marks represent problems in your manuscript and should be revised.

Verbal Communication Skills

Verbal communication skills are also learned by participating. I'm not going to say much about this aspect of a biologist's job. In my view, any biologist worth his salt seeks opportunities to become part of the "Rubber Chicken" circuit, speaking to angling groups and conservation organizations about current projects, resource management programs, and local resources. Don't wait to be asked, become proactive.

Place yourself on constituent mailing lists and volunteer to present programs at least once a year or more, where you discuss projects, area resources, and potential management options.

Making management changes becomes much easier, when constituent groups know you personally, have developed a working relationship, and have received information regularly about potential changes. Anglers like to feel a part of the management process. This can be a series of regular talks; invitations to observe or participate in sampling excursions; or short updates in newsletters.

Supervisors

Most supervisors are biologists by training. They are good technical editors; understand technical formats, and how technical papers are written. They don't understand, however, popular formats or what it takes to produce a publishable popular article for a magazine, newspaper, website, or even a newsletter.

They also feel insecure when biologists work outside the traditional agency role and structure. This feeling results in over editing, restricted annual budgets, and narrowly defined job objectives. This frustrates biologists, increases the workload, and ultimately reduces an individual's incentive to become better communicators and better promoters of agency programs.

To change this, supervisors need to attend and participate in the same writing and editing workshops as biologists; encourage biologists as part of their job responsibilities to become involved with constituents through annual work plans and objectives; and encourage professional staff to function as a frontline information source for anglers affected by fisheries programs, rather than leaving this to I&E staff.

In the long run, this will make management and regulation changes much easier and less controversial; professional staff will feel a part of the management process, rather than simply the person doing grunt work; and it will make your job much easier. Trust your staff, provide an atmosphere supporting and encouraging the development of good communication skills and proactive involvement with constituent organizations.

Summary

Good communication skills, both the written and the spoken, are best learned by participation, editing, rewriting, and rewriting, and rewriting. Written and spoken communication skills are a learned art form. Computers and word processors take most of the physical work out of the process, leaving the creative and technical skills to be melded to informing constituent groups. Supervisors need to be part of the process, providing administrative support to allow communication skills of professional staff to grow and mature.

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Ecological, Social, and Economic Issues Related to Bioinvasive Salmonid Species and the Preservation of Cutthroat Trout in the Western United States

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ABSTRACT—Ecological, social, and economic consequences of native cutthroat trout (*Oncorhynchus clarki*) declines and replacement by non-native salmonid species are relatively minor, and measurable effects on ecosystems are rare. Restoration efforts for cutthroat trout involve removal or control of bioinvasive salmonid species, but such efforts are costly, ongoing, and resisted by segments of society. Cutthroat trout declines are of little concern to much of the public because non-native salmonid species frequently have higher recreational values. Net economic benefits of preserving cutthroat trout are equal or less than for non-native salmonids. Realistic goals to preserve cutthroat trout that consider ecological, social, and economic issues are needed.

Introduction

Preserving native cutthroat trout (*Oncorhynchus clarki*) in their natural habitats is dependent on not only understanding ecological systems, but also social and economic issues. Our purpose is to describe ecological, social, and economic issues associated with control of bioinvasive salmonids in efforts to preserve native cutthroat trout in the western United States. Clear understanding of these issues is critical when planning restoration efforts for native cutthroat trout. This article is a synthesis of issues described in a published paper by Quist and Hubert (2004).

Cutthroat trout had the broadest distribution of any trout species in North America (Behnke 2002). Behnke recognized 14 subspecies of cutthroat trout, nearly all of which have been reduced to <5% of their distributions since settlement by Europeans. Two subspecies of cutthroat trout are extinct, three subspecies are federally listed as threatened, and several subspecies have been petitioned for protection under the Endangered Species Act.

Ecological Issues

A variety of factors have been associated with cutthroat trout declines, but the most significant impact may be interactions with non-native, bioinvasive salmonid species. Four non-native species have had the greatest impacts on native cutthroat trout: rainbow trout (*O. mykiss*), brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), and lake trout (*Salvelinus namaycush*). Behnke (2002) stated “The greatest negative impact, however, has been introductions of non-native trout, especially rainbow trout, with which cutthroat trout hybridize; but also brown trout, which replace native cutthroat trout in larger streams; brook trout, which have commonly replaced cutthroat trout in small streams; and lake trout, which replace cutthroat trout in large lakes.”

The ecological argument for cutthroat trout preservation is limited if the focus is on ecosystem function (Quist and Hubert 2004). Replacement of cutthroat trout with non-native salmonid species may affect ecosystem function by altering energy and nutrient flow. Due to their similar ecology, replacement of cutthroat trout with rainbow trout or cutthroat trout x rainbow trout hybrids results in little or no measurable effects on ecosystem function. The ecology of brook trout is similar to cutthroat trout in stream systems and replacement of cutthroat trout by brook trout likely causes little change in energy flow, nutrient flow, or ecosystem productivity. However, changes in fish assemblage structure, including reduction in native cutthroat trout abundance, due to predation by adult brown trout and lake trout can result in alterations to ecosystem function. Lake trout pose a major threat to lentic ecosystems where cutthroat trout are native. Nevertheless, lake trout probably pose the lowest threat of the four non-native salmonids to the persistence of cutthroat trout subspecies because the lake trout is predominantly a lentic species.

Social Issues

The value placed on preservation of native cutthroat trout has increased among natural resource professionals, but public support generally differs. An understanding of public values related to cutthroat trout and bioinvasive salmonids is critical for obtaining support for preservation activities. Social values can be divided into four major categories: ethical, aesthetic, historical, and recreational (Quist and Hubert 2004).

Ethical values originate from the belief that organisms have intrinsic value and deserve protection from destruction by human activities. The notion that species' declines are an indicator of changes to overall environmental health and that humans have a moral responsibility to protect the integrity of ecological systems for future generations can also be considered an ethical value, and is the belief held by most ecologists. However, the public may not be supportive of these ethical values.

Aesthetic values are associated with observing the natural beauty of organisms in their habitats. Although viewing cutthroat trout is a popular activity in Yellowstone National Park, observing them is not a common activity elsewhere. Replacement of cutthroat trout with non-native trout has no effect on the scenic or aesthetic beauty of the landscape. Thus, there is little evidence to suggest that aesthetic values differ greatly between cutthroat trout and non-native salmonids.

Historical values represent the role of a species in the history of a particular water body, region, or individual. Cutthroat trout supported a few commercial and subsistence fisheries that helped shape local cultures, but the historical values of cutthroat trout to most of the public are either unknown or extremely low.

The social value with the greatest discrepancy between cutthroat trout and non-native salmonids is probably recreational angling. Cutthroat trout, rainbow trout, brook trout, brown trout, and lake trout support important recreational fisheries, but replacement of cutthroat trout with non-native species has generally had little negative effect or even positive effects on recreational fisheries in the perspective of many anglers. Cutthroat trout are often considered inferior to other non-native salmonids due to their perceived ease of capture, poor sporting ability (e.g., jumping ability, stamina), and low maximum length. This belief is reflected in angler surveys where there is either little preference among trout species or strong preference for non-native salmonids over cutthroat trout.

Economic Issues

Protection of native cutthroat trout from non-native, bioinvasive salmonids is related to economics (Quist and Hubert 2004). Net economic effects associated with bioinvasion of non-native salmonids into a cutthroat trout fishery are contingent on the values society places on each species. In economics, "substitution" reflects the concept where an alternative commodity substitutes equally for a commodity that has become depleted or too expensive to purchase or supply. Non-native salmonid species may be viewed as ecological and social substitutes in most ecosystems and their bioinvasion has no effect on net benefits from the fishery. Rainbow trout, brown trout, and even brook trout, are often preferred by anglers over cutthroat trout throughout the western United States and their invasion can result in increased economic benefits. Consequently, in most fisheries, there is little or no demand for cutthroat trout preservation and cutthroat trout preservation incurs only additional cost without concurrent economic benefit.

Control of Bioinvasive Salmonids

Once an introduced salmonid species has become naturalized, their removal is impossible except at small spatial and temporal scales. Active approaches for reducing or preventing interactions between non-native salmonids and cutthroat trout have become an important component of cutthroat trout preservation efforts. Reducing the effects of competition and predation on cutthroat trout has been successful in some ecosystems by removing the non-natives with gears, such as gill nets, trap nets, or electrofishing. However, complete removal of non-native species with such gears is not possible, so consistent, high levels of effort are needed to reduce the impacts of competition and predation. Such efforts to reduce the abundance of non-native salmonids can be resisted where sport fisheries for the non-natives have developed.

A common approach to the preservation of cutthroat trout in headwater streams is the intentional isolation of allopatric populations. This can involve the identification of remnant populations and construction of barriers to prevent upstream movement by non-native salmonids. Where non-native salmonids occur in headwater streams, attempts are made to remove them using toxicants, followed by restocking with cutthroat trout. Removing all non-natives from a stream segment is often difficult or impossible, even with multi-year treatments. Anglers may resist non-native fish removals and reintroduce non-native fish above barriers, thereby hindering efforts to re-establish populations of cutthroat trout. While barriers and re-establishment of cutthroat trout populations above barriers may protect cutthroat trout, protected populations may be too small or have inadequate habitat to enable long-term population viability, and barriers may deteriorate or fail during floods. Consequently, efforts to create isolated allopatric populations of cutthroat trout in headwater streams require consistent monitoring and frequent repetition following failed attempts.

Reality dictates that cutthroat trout preservation efforts incur significant costs that are ongoing. Obtaining funds for preservation of cutthroat trout is difficult for management agencies and nongovernmental organizations dedicated to the cause. There can be little or no social or economic support for control of rainbow trout, rainbow trout x cutthroat trout hybrids, brown trout, lake trout, or brook trout in many systems where sport fisheries for non-natives are valued. Control efforts can be justified based on evolutionary and ecological values, but these may not be recognized as important to the public or many anglers. Thus, management agencies and nongovernmental organizations interested in cutthroat trout preservation must convince the public that preservation activities are needed, responsible actions. Furthermore, agencies and nongovernmental organizations must be realistic and realize that only a relatively small number of cutthroat trout populations can be preserved in the long term, because the costs to preserve cutthroat trout are real and represent a significant fixed cost to management. Realistic goals and expectations and cooperative agreements must be established to assure that projects are completed, routine monitoring is conducted, success is objectively evaluated, and identified maintenance needs are instituted for each of the cutthroat trout subspecies.

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In Defense of Natives: Why Protecting and Restoring Native Trout Should Be Our Highest Management Priority

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ABSTRACT—Native salmonids, including both inland resident trout and anadromous Pacific salmon and steelhead, have declined sharply across the western United States due to overfishing, habitat degradation, and interactions with non-native fish. While fisheries managers, anglers, and conservationists generally agree that native trout should be preserved in core strongholds such as Yellowstone Lake, there remains considerable debate about the degree to which native trout should be restored to waters now dominated by non-native gamefish. In this paper, the author argues that native trout will eventually disappear from the West unless these constituencies work together to establish large, permanently protected native fish sanctuaries in places such as the headwaters of the Snake River drainage in northwest Wyoming and the Upper Henrys Fork drainage in eastern Idaho. The author cites ecological, scientific, economic, cultural, and moral/spiritual justifications for making native trout preservation a top management priority.

Status of Native Trout in the Western U.S.

Native salmonids have declined sharply across the western United States due to a combination of overfishing, habitat degradation, and interactions with non-native fish. These declines have occurred among both resident (Williams et al. 1989) and anadromous (Nehlsen et al. 1991) fish. Today, all native trout species in the West are in serious trouble, with nearly half now listed under the federal Endangered Species Act, and the remaining species petitioned for listing.

Even within the Greater Yellowstone Ecosystem (GYE), one of the largest intact temperate ecosystems left in North America, native trout now occupy just a small fraction of their historic range. While habitat degradation in the form of road building, logging, mining, grazing, and dam construction has played a major role in this decline, native trout have also declined within National Parks and Wilderness areas primarily due to interactions with non-native fish. Van Kirk (1999) found that native cutthroat (*O. clarki spp.*) have either been extirpated, declined in abundance, or had their migration patterns severely disrupted in 33 out of 41 sub-watersheds in the GYE. Among the most frequently cited impacts of non-native fish introductions are predation, hybridization, competition for food, competition for habitat, and disease transmission (Lassuy 1995).

Perhaps most alarming is the recent data showing steep declines in native cutthroat trout even in some of their core strongholds in the GYE. In Yellowstone Lake, home the world’s largest remaining population of genetically pure inland cutthroat trout, Yellowstone cutthroat trout (*O. clarki bouvieri*) have declined to their lowest level since 1959 as a result of heavy predation by non-native lake trout (*Salvelinus namaycush*) and a severe outbreak of whirling disease (*Myxobolus cerebralis)* (Koel et al. 2003). In the South Fork Snake River, home to the second largest fluvial population of Yellowstone cutthroat trout within their historic range (the Yellowstone River is home to the largest), cutthroat numbers have plunged by half since the 1980s, and non-native rainbow trout (*O. mykiss*) now outnumber native cutthroat for the first time (Idaho Department of Fish and Game 2003). And in still other eastern Idaho strongholds such as the Teton and Upper Blackfoot Rivers, Yellowstone cutthroat trout populations have crashed by more than 90 percent over just the past five years as a result of drought and a surge in non-native fish populations (Idaho Department of Fish and Game 2003b).

Native Fish Restoration: How Much is Enough?

Clearly, many native cutthroat trout populations are in danger of disappearing from the GYE over the next few decades unless dramatic actions are taken to protect them in their remaining strongholds and restore them where they have declined in abundance. While the vast majority of fisheries managers and anglers agree that native fish should be protected in places where they remain healthy (e.g. Yellowstone Lake), the degree to which native fish should be restored to waters now dominated by non-native gamefish such as rainbow, brown (*Salmo trutta*), brook (*Salvelinus fontinalis*), and lake trout remains hotly contested. To cite just a few recent examples, the angling community remains deeply divided over ongoing efforts to restore native westslope cutthroat trout (*O. clarki lewisi*) to 77 miles of Cherry Creek, a tributary to the Madison River in southwest Montana, by poisoning out non-native rainbow, brook, and cutthroat trout. Opposition to that project was so strong that one sportsmen's group filed an unsuccessful lawsuit to stop the project from proceeding (Williams 2002). Similarly, many anglers were incensed when the Idaho Department of Fish and Game (IDFG) announced an end to the brook trout stocking program in Henrys' Lake in the late 1990s in order to avoid possible negative interactions with native Yellowstone cutthroat trout. Responding to this outcry, the IDFG reversed course a few years later and resumed the brook trout stocking program, albeit at lower levels and with sterile fish (Thornberry 2002).

The debate over how high a management priority native fish protection and restoration should be continues despite the fact that the nation's leading fisheries conservation organizations have adopted strong native fish policy statements in recent years. For example:

- The American Fisheries Society calls on managers of recreational and commercial fisheries to "use practices that do not threaten the viability of populations of native species of aquatic and terrestrial organisms, their habitats, and their ecosystems (Kapuscinski and Hallerman 1990)."
- Trout Unlimited (TU) supports activities that protect and/or restore native biodiversity, including such actions as restoring native salmonid stocks to their formerly occupied habitats; eliminating non-native stocking where it could adversely affect native salmonid populations; and preventing native and wild salmonid stock introgression caused by mixing historically isolated populations of salmonids. While TU does not necessarily advocate the removal of wild, non-native salmonid populations from ecosystems where they are presently established, it acknowledges that it may be required on a case-by-case basis to protect

or restore native salmonids or endangered species (Trout Unlimited 1997).

- The Federation of Fly Fishers (FFF), "supports fisheries management policies that recognize the value of native species in their native habitats, and does not support management policies that threaten native species with degradation or extinction." As for restoring native species where they have declined, FFF acknowledges that the removal of introduced non-native species from specific streams may be required under some circumstances, but that should not be construed as an unwavering policy to eliminate all non-native fish everywhere (Williams 2001).

Reasons for Protecting and Restoring Native Fish

There are multiple reasons why fisheries managers, anglers, and conservationists should advocate for making native fish protection and restoration not just a high priority, but the *highest* management priority in waters where they persist. These reasons can be classified under the following headings: (1) ecological; (2) scientific; (3) economic; (4) cultural; and (5) moral/spiritual. Although there are also *legal* reasons for preserving native fish (e.g. the Endangered Species Act requires not only that listed fish species be protected, but also recovered), they have been omitted from this discussion because they are a product of the other justifications.

Ecological

This justification is based on the premise that native fish fill unique niches in the ecosystems in which they evolved. The role that native Yellowstone cutthroat trout play in Yellowstone Lake is a good example of this. Following the discovery of highly piscivorous non-native lake trout in Yellowstone Lake in 1994, researchers documented 42 bird and mammal species that utilize Yellowstone cutthroat trout as an important seasonal food source, including up to 20 percent of the Park's grizzly bears. But if lake trout, which live deep in the water column and spawn along submerged gravel shoals, were to displace cutthroat, which live near the surface of the lake and spawn in shallow tributary streams, these wildlife species would lose access to a major protein source (Varley and Schullery 1995).

Yellowstone Lake provides an obvious example of how the displacement of native cutthroat trout by non-native lake trout would cause a major trophic upheaval. But what about instances where one surface dwelling, tributary spawning native fish is displaced by another surface dwelling, tributary spawning non-native fish? An example of this is the displacement of native westslope cutthroat trout by non-native rainbow and brown trout in southwest Montana's Gallatin River. While it may not matter to an osprey or a river otter whether they feed on cutthroat or rainbow trout, there are other compelling ecological reasons why such a displacement could result in fewer fish in the longer term. For instance, research shows that in most cases, native cutthroat trout are less susceptible to whirling disease than rainbow trout (Hedrick et al. 1999). Also, because they evolved over thousands of years to survive and thrive in an environment characterized by frequent severe droughts and floods, native cutthroat trout are oftentimes better equipped than rainbow trout to survive a variety of extreme environmental conditions (Behnke 1992).

Scientific

This justification is predicated on the belief that all native species should be preserved because they contribute to the overall scientific body of knowledge and help foster a better understanding of the way ecosystems work. Congressman John Dingell of Michigan, one of the original sponsors of the Endangered Species Act, articulated this justification eloquently when he said, “Living wild species are like a library of books still unread. Out heedless destruction of them is akin to burning that library without ever having read its books. Preventing the extinction of our fellow creatures is neither frivolity nor foolish environmental excess; it is the means by which we keep intact the great storehouse of natural resources that make the progress of medicine, agriculture, science, and human life itself possible (Rohlf 1989).”

Scientists are continually discovering new things about how ecosystems function by studying native salmonids. For example, through recent research that traces the movement of certain stable isotopes of carbon and nitrogen from marine to terrestrial environments, biologists now have quantitative evidence showing the key role that Pacific Northwest salmon play in growing exceptionally large trees (Cederholm et al. 1999). As a result of this research, commercial timber companies now dump surplus hatchery salmon carcasses into streams that flow through their private timberlands.

Another way scientists use native salmonids to conserve ecosystems is by using them as indicator species. For example, because certain salmonids such as bull trout (*Salvelinus confluentus*) require exceptionally cold, clean, well-oxygenated water, biologists in the Pacific Northwest now use them as a surrogate to gauge the health of aquatic ecosystems.

Economic

For fishing guides and outfitters and other businesses that benefit from angling-related tourism, one of the most compelling reasons for preserving native trout is that they generate millions of dollars for local economies. For example, a study of the potential economic impacts of the non-native lake trout invasion in Yellowstone Lake revealed that the cutthroat fishery in the Lake and adjoining Yellowstone River was worth $36 million annually to communities like West Yellowstone and Gardiner, Montana (Varley and Schullery 1995). If the lake’s cutthroat fishery were to be replaced with a lake trout fishery, the latter would likely generate considerably less income because lake trout would be far fewer in number, more difficult to catch, and require boats to access them.

Similarly, biologists point out that one of the main reasons why anglers from around the world are drawn to the South Fork Snake River in eastern Idaho is because it harbors a healthy population of large Yellowstone cutthroat trout, which are quick to rise to dry flies. If the cutthroat population were to be displaced by non-native rainbow trout, as is the current trend, overall catch rates would decline, which could result in lower angler satisfaction and fewer angler visits.

Cultural

Another reason why conserving native trout should be a top management priority is because, just like historic buildings, unique landscapes, and cultural heritage, they help define the places where we live. There is a reason why every state in the western U.S. has designated either a native cutthroat trout, native rainbow trout, or native salmon as their official state fish – because they help define what makes those places special. If we allow the few remaining populations of native Colorado River cutthroat trout to disappear from Wyoming, or let the last remaining populations of westslope cutthroat trout vanish from Montana east of the Continental Divide, we compromise part of our unique western identity and become more like other regions of the country where wildness is no longer a part of the landscape.

Perhaps no sub-group of people within our society treats native fish as such an important part of their cultural identity as Native Americans in the Pacific Northwest. When asked by a reporter how important it was to keep wild salmon from going extinct in the Columbia River, Antone Minthorn, chair of the Confederated Tribes of the Umatilla Indian Reservation in Oregon, replied: "How can I tell you what salmon are worth to me? The salmon are who I am."

Moral/Spiritual

A final reason why native fish should be preserved is that they have an inherent right to exist. In his 1978 book, *The Arrogance of Humanism*, Professor David Ehrenfeld writes that species should be conserved "because they exist and because this existence is itself but the present expression of a continuing historical process of immense antiquity and majesty (Ehrenfeld 1978)." Among Native Americans in the Pacific Northwest, there could be no higher justification for saving native fish than for spiritual reasons. In the book, *Salmon and His People*, Nez Perce tribal member Jamie Pinkham writes: "Fish provide us with both physical and spiritual sustenance. Other cultures seem unable to recognize how those two concepts go hand in hand. Instead, they see them as separate: traditional beliefs on one side, science on the other. For Indian people those concepts have never been separate. Our fate and the fate of fish are linked (Landeen and Pinkham 1999)."

Conclusion

Regardless of which justification or combination of justifications one uses to argue for native fish conservation, the questions remains, what must we as scientists, anglers, and conservationists do to ensure that native trout not only persist, but are also restored to major portions of their historic range throughout the West? I believe we need to do three things. First, we must permanently protect in a network of native fish sanctuaries those core habitats where healthy metapopulations of native trout persist. This protection should come in two forms. First, we must ensure that the aquatic habitats that harbor these native fish populations are not further degraded by dams, roadbuilding, logging, mining, grazing, energy development, or other potentially damaging activities. And second, we must implement harvest regulations and stocking practices that are designed to minimize adverse impacts to native fish.

The idea of creating native fish sanctuaries is not a new one. In 1892, U.S. President Benjamin Harrison created the Afognak Forest and Fish Culture Reserve on Afognak Island in Alaska with the intention of permanently protecting Pacific salmon runs (Rahr et al. 1998). Unfortunately, the concept never caught on, although federal Wilderness and Wild and Scenic River designations have created de facto native fish sanctuaries in places like the Middle Fork Salmon River drainage in central Idaho and the North Fork of the John Day River drainage in Oregon. An example of a place in the GYE that would make an ideal native cutthroat trout sanctuary is the headwaters of the Snake River drainage in northwest Wyoming.

But if we truly want to preserve native trout in the West as more than just museum pieces, it will not be enough to simply create sanctuaries in existing native fish strongholds. We must go one step further and create new native fish strongholds in places where remnant native fish populations co-exist with non-native fish in compromised environments. A good example of such a place in the GYE is the Upper Henrys Fork drainage from Henrys Lake downstream to Island Park Reservoir. Historically, Yellowstone cutthroat were the only trout native to the Henrys Fork drainage. Today, they have been displaced by introduced rainbow trout virtually everywhere in the drainage except Henrys Lake, which to this day is heavily stocked with rainbow/cutthroat hybrids and brook trout. While creating a native cutthroat sanctuary in the Upper Henrys Fork would pose an exceedingly difficult challenge in terms of eliminating non-native fish, restoring degraded habitat, and garnering public support, it is just the sort of action that will be required to conserve native trout across large expanses of the landscape.

Finally, we must do everything we can to protect isolated native fish populations that possess unique genetic characteristics or live at the geographic or environmental fringes of their range. There are at least two good reasons for doing this. The first is that these populations contribute to the overall genetic diversity of a species, which improves its chances of persisting over time. For example, some native redband trout in the Great Basin have adapted to survive in streams and lakes that routinely reach temperatures of 26 degrees Celsius or higher in summer, an environment in which virtually no other salmonids could survive (Behnke 1992). If climate predictions are correct and the West continues to get warmer and drier, these desert redbands may be the only form of inland rainbow trout that are still around 100 years from now. A second reason to preserve isolated native fish populations is that they serve as a hedge bet in the event that non-native trout disappear from other areas due to unforeseen future events. For instance, if a new disease were to selectively wipe out all the non-native rainbow trout in Montana’s Madison River, biologists theoretically could re-seed the river with native westslope cutthroat trout that have a resistance to the disease.

Ultimately, society as a whole is unlikely to support native fish protection and restoration until we as fisheries managers, anglers, and conservationists first convince ourselves that it is the right thing to do, which has yet to fully happen as demonstrated by the need for this panel discussion. As the acclaimed outdoor writer Ted Williams wrote in a recent issue of *Audubon*: “Managers need to quit trying to figure out what native trout can do for us and attempt a new approach. Maybe it starts with a simple statement that these fish are priceless works of art that need to be protected for themselves, for the species that need them, and for people who cherish them for what they are and because they are (Williams 2002).” Perhaps when that paradigm shift occurs we can begin to think big enough, act boldly enough, and move swiftly enough to accomplish the daunting task before us.

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Partnerships in Trout and Native Fish Management—an Australian Case Study

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ABSTRACT—Australia's recreational fisheries include trout introduced in the 19th century. In the State of Victoria, trout angling has benefited from regulation of major streams such as the Goulburn River. River regulation has impacted on native species and there is tension between trout and native fish advocates. Fisheries managers need to identify common objectives aligned to both trout anglers' wishes and the community's desire for conservation of threatened native species while facilitating the economic and social benefits that trout bring. The conflict can be dealt with by fisheries management planning conducted through independent co-management structures including fish stocking based on agreed translocation principles. A model 5-year inland fishery management plan for Victoria's Goulburn River Basin has exposed trout angling advocates to the needs of native fish identified in the State's river health management practices. A Partnership Committee has been established to oversee implementation. The committee features direct co-operation with wider stakeholder groups to ensure balanced outcomes for both trout and native fish. Where conflict exists between trout and native fish advocates the focus of recreational management must be on establishing partnerships that positively influence trout anglers to support biodiversity and water and catchment management programs that improve the quality of all fisheries.

Introduction

The impact of trout on native fish stocks in Australia is still not fully understood and, as a consequence, is controversial. There is a perception that management must favor either trout or native fish. In practice, the task of fisheries management is to achieve balanced outcomes in the face of changing habitat and native fish stock status and within a complex framework of dynamic Government policies on resource utilization and socio and economic objectives.

A focus area for the 'conflict' is the Goulburn River in Northeast Victoria. The upper catchment (Figure 1) of the Goulburn is 2% of the surface area of Australia's Murray Darling Basin and 8% of the water resources (UGWP 1998) including Victoria's principal irrigation supply dam, the 3,390,000 megalitre capacity Lake Eildon. Much of the catchment is seen as a degraded native fish habitat and there is strong public pressure for rehabilitation of native fish stocks within it.

It is also Victoria's premier trout fishery with eleven wild trout (i.e., self-sustaining) stream fisheries and a number of put and take fisheries such as the Eildon Pondage.

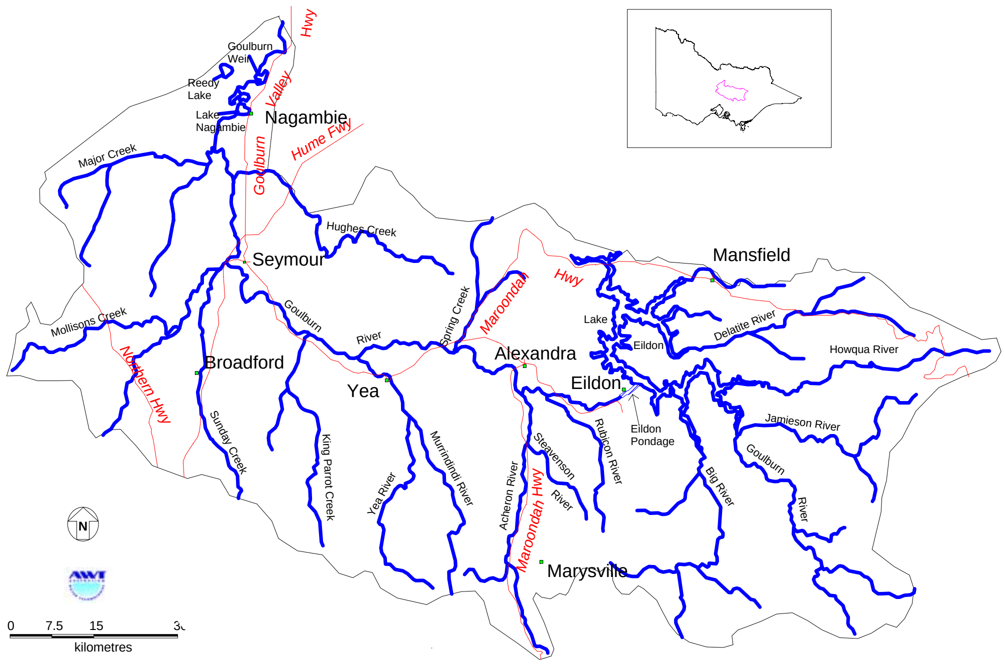

Figure 1. Goulburn River Catchment

Victoria's Recreational Fisheries

Australia has a mixed range of freshwater finfish species that anglers target including the native *Maccullochella peeli* (Murray cod), *Macquaria ambigua* (golden perch), *Bidyanus bidyanus* (silver perch), *Tandanus tandanus* (freshwater catfish) and the introduced *Salmo trutta* (brown trout) and *Oncorynchus mykiss* (rainbow trout). Nearly 550,000 Victorians fish annually as part of their recreational pursuits, with a significant portion of effort occurring on inland waters (43%). This is significantly more than the national average (20%) (NRIFS 2003).

Trout

Fisheries Victoria currently assume responsibility for the bulk of trout stocking. In the last 40 years the number of trout released annually has decreased from about 2 million to between 330,000 and 430,000. The number of waters has similarly decreased from over 180 (mean for 1960-64) to around 100 in 2002. These reductions recognize that many streams now support wild trout populations (Winstanley 2001). Trout still account for 70% of Fisheries Victoria's annual stocking costs.

Native fish

In comparison with trout, native fish numbers have been severely impacted in Australia post-European settlement (MDBC 2003). The first State government funded stockings of hatchery-produced Murray cod in Victorian public waters occurred in 1980/81 when 6,000 juveniles were released. Since then the number of Murray cod released annually has steadily increased with the Department of Primary Industries stocking the bulk of Murray cod into public waters (Winstanley 2001).

Table 1. Trout / Salmon and Native fish stocking between 1993 and 2003

Year	Trout / Salmon	Native fish	Totals
1993	400,247	193,742	**593,989**
1994	515,004	661,907	**1,176,911**
1995	584,921	728,429	**1,313,350**
1996	406,252	606,820	**1,013,072**
1997	450,745	670,651	**1,121,396**
1998	378,717	720,080	**1,098,797**
1999	340,150	775,331	**1,115,481**
2000	386,175	575,638	**961,813**
2001	333,587	690,170	**1,023,757**
2002	329,814	970,875	**1,300,689**
2003	331,951	621,060	**953,011**
Total	**4,457,563**	**7,214,703**	**11,672,266**

Source Department of Primary Industries data

River regulation impact on native species

The provision of water for irrigation has reduced total flows and significantly changed the seasonal flow patterns and flood frequencies in almost all of Victoria's northern flowing rivers. The cold water released from major dams during Spring reduces spawning opportunities and survival rates for native fish.

Tension between Trout and Native Fish Advocates

Conservation of endangered species

There are ongoing endeavors to restore the native fisheries. For example in Australia's Native Fish Strategy for the Murray Darling Basin, one aim is to rehabilitate native fish species to 60% of their pre-European populations over the next 50 years (MDBC 2003).

The strategy recognizes that recreational fishing stakeholders ‘should be encouraged’ to play a major role in rehabilitating native fish populations. It doesn't however identify the public value of introduced recreational fish species and some of the proposed actions have the potential to adversely affect wild trout angling and to alienate anglers and tourism interests that might otherwise support the strategy.

Fisheries Victoria thus sets targets for rehabilitation of native fish in the context of obligations to preserve established trout fisheries where possible. (Victoria has several rivers protected under the Heritage *Rivers Act* where the river's value as a trout fishery was identified in granting the heritage status). In doing so it also recognizes it has obligations to manage actions that threaten native fish which are listed as threatened under the *Flora and Fauna Guarantee Act, 1988.*

Economic and Social Benefits of Trout Fisheries

The trout fishery is unique in the State in that it is managed purely for the social and economic benefits that it provides to the community (Winstanley 2001). Anglers' spending on fishing tackle, bait, licenses, boats, fuel, transport, meals, accommodation and fishing guides provides significant input to regional economies. In 1997, Northeast Victoria generated $AUD 118.8 million (or 11.4%) of the gross angling expenditure on recreational fishing in Victoria and attracted 17.6% of all angling fishing activity in the State (FEIS 1997). Brown and rainbow trout are the most popular species sought in the region being the preferred catch for over 70% of anglers.

Discussion

Managing the Fisheries

A key feature of recent developments in Australian fisheries management has been the acceptance of a broad range of rationales and justifications. These include increasing community awareness of the need for conservation and sustainable use of finite fish resources and the magnitude and socio-economic significance of recreational fishing activities (Winstanley 2001).

Native fish and river health plans

Victoria has an integrated environmental management multiplan framework (Figure 2) encompassing river health, water entitlements, streamflow management and biodiversity maintenance (NRE 1997). It sets the directions for all the major management functions in rivers and their associated floodplains and wetlands, and

- identifies environmental, recreational, cultural, social and economic assets for the State’s waters, the current condition of the asset vs. community values (including recreational fishing);
- identifies processes threatening these values and the severity of the risk involved;
- identifies opportunities for restoration of degraded values and requirements for restoration;
- sets broad priorities for action and the key specific actions required.

Issues are integrated and articulated as river health objectives within each catchment. This approach delivers many of the desired outcomes that lead to rehabilitated native fish populations.

Goulburn Eildon Fishery Management Plan

This framework introduced a new complexity into the development and introduction of Victoria's first inland Fishery Management Plan. Within it, Fisheries Victoria's managers set out to encourage maximization of the opportunities provided by **both** wild trout and the native fish resources. Our objectives included:

- provision of a wide variety of fishing experiences with year-round fishing opportunities for both native and introduced species;
- development of both fisheries to their full sustainable potential;
- promotion of improvements in relation to a wide range of threatening processes; and
- involvement of all stakeholders in the fisheries management process.

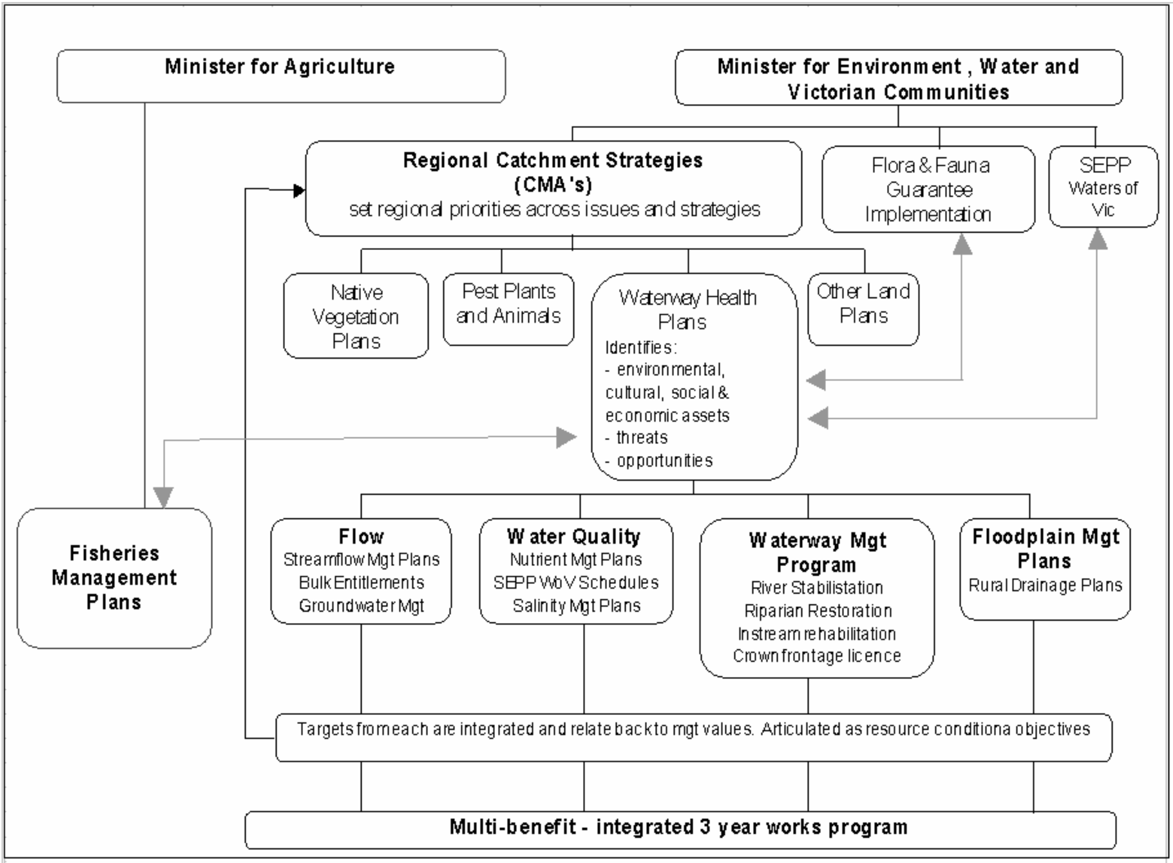

Figure 2. Victoria's Environmental Planning framework

It became clear quite early in the process that the environmental planning framework and its emphasis on river health reinforced trout anglers' views that Government favored native fish over trout. On the other hand water management practices led the community to the belief that trout were favored over native fish. To counter this conflict a stepped methodology for the planning process was developed, including: -

1. a discussion paper to expose the issues and management objectives and strategies and
2. public meetings in local population centers for confirmation of the issues and feedback on the management options

This process developed stakeholder recognition that two fundamental factors determine what is possible in terms of fisheries management in the Goulburn River, the irrigation water release practices and the water temperature regime that results during the irrigation season. This realization during the phased consultation process allowed balanced strategies to be developed.

Co-management

Fishery Management Plans are developed under the *Fisheries Act, 1995*. The Act establishes an independent Fisheries Co-Management Council comprised of industry stakeholders outside Government to drive the management process.

Co-management aims to bring all stakeholder groups together and create a shared vision for the future of Victorian fisheries. It plays a pivotal role in enabling communication and consensus building within the planning process and in achieving balanced outcomes that provide for both trout and native recreational fisheries.

Implementation Partnerships

In striving to work through the trout v native fish conflict, the strengthening of partnerships is critical to the credibility of the commitments made during plan formulation.

At a broad level, Victorian fisheries management arrangements are led by the Department of Primary Industries (Fisheries Victoria and Northern Region). A sister agency, the Department of Sustainability and Environment, in partnership with Catchment Management Authorities and Water Management agencies coordinate inputs to environment and biodiversity plans and programs. A coalition of these government stakeholders and representatives of trout anglers, water managers and others meet regularly to integrate actions to implement the Fishery Management Plan into the individual stakeholder's activities. This coalition reports annually against performance measures included in the fishery management plan.

Associated Stocking Principles

The dynamic planning process has also been a catalyst in managing wider conflict in respect to fish stocking generally.

A new stocking policy framework

The release of any fish species into rivers and streams now occurs within strict guidelines (DPI 2003). The risks of stocking are determined to be either minimal, acceptable or manageable and proposed stockings that do not conform to the guidelines are required to undergo a risk-assessment funded by the proponent (Figure 3).

Table 2. Summary of fish stocking environmental risks and proposed management response

Risk Category	Description	Risk Management Response
Environmental/ ecological risks	Genetic shift in wild populations and hybridization	Appropriate sourcing of brood stock Maintaining sufficient pools of brood stock
	Establishment of feral populations	No stocking where there is documented risk to endangered species.
	Translocation of associated species	Surveillance and monitoring programs Stock certification Treatment of transport vehicle and medium
	Interaction with native species and/or habitat alteration	Limit the number of species to be stocked; Stock only within the natural range of the proposed species or in waters where the proposed species has been recently stocked (since 1995); or No stocking where there is documented risk to endangered species.

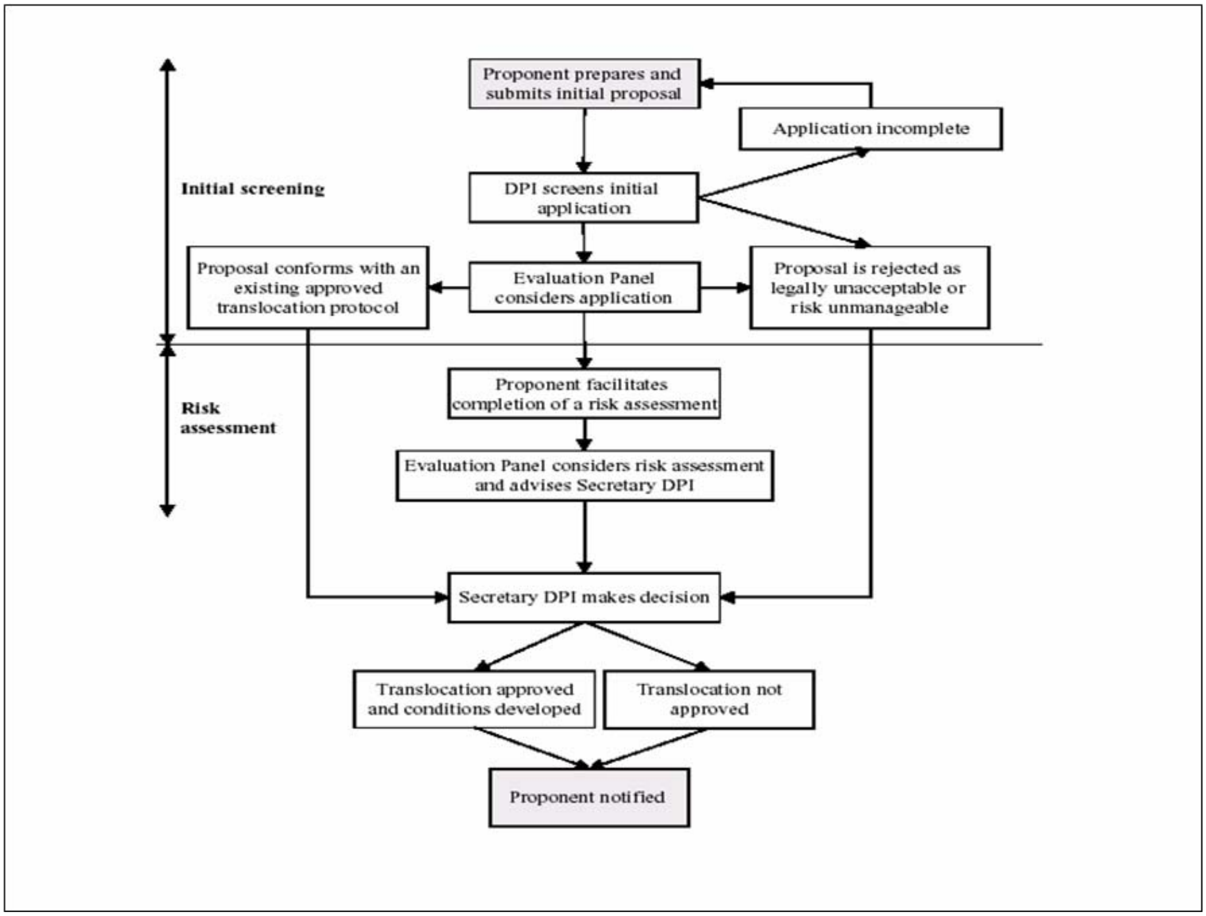

Figure 3. Stocking Risk Assessment

Balanced Outcomes

Examples of specific outcomes within the Goulburn catchment that have benefited both native and trout anglers (and reduced tension between the two groups) since the coordinated approach commenced include:

Identified habitat preferences of large trout and golden perch in impoundments

Radio tracking of both species has determined habitat associations that have opened up extra dimensions in the Lake Eildon recreational fishery assisting anglers to better target golden perch.

Developed knowledge of trout movement in the Goulburn River

Radio tags have been used to determine the habitat used by catchable size brown trout under high and low flow conditions in the Goulburn River assisting anglers to better target trout.

Fine-tuned recreational fishing impact on endangered wild native fish species.

A joint whole of government evaluation has concluded that anglers have no apparent significant impact on threatened native species (e.g. Murray cod and Golden Perch) within the Goulburn catchment.

Protection of dead timber as fish habitat

Standing and fallen dead timber has been protected in Lake Eildon to secure important fish habitat for native species such as Murray Cod.

Work yet to be done

A principal issue yet to be resolved is the possibility of engineering a rise in the temperature of the water released into the Goulburn River from Lake Eildon and modifying water delivery practices to improve the status of native fish within this river system.

Depending on what delivery changes were made and how much the water temperature was changed, at what time of the year and for how long and what engineering and delivery point solutions were used, both native and introduced trout and all anglers could potentially benefit.

Conclusions

Balanced freshwater fishery management in Australia is demonstrating that trout fishery management can limit impacts on native species.

A focus on establishing partnerships positively influences both trout and native species anglers to support biodiversity, water, and catchment management programs that improve the quality of all fisheries.

The major pay-off will be growing community confidence that maintaining a productive wild trout fishery does not in itself threaten native fish conservation in Australia.

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Managing the Threat Posed by Lake Trout to the Lake Pend Oreille, Idaho, Fishery

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ABSTRACT—Non-native lake trout have had significant negative impacts on native bull trout and other popular sport fisheries in lakes in the northern Rockies. Evidence of a rapidly expanding lake trout population and declining kokanee population in Lake Pend Oreille (LPO), Idaho, prompted significant fishing regulation changes in 2000. Two years of predator reduction efforts and no improvement in the kokanee population prompted an intensive angler involvement program to define and implement socially acceptable means of predator reduction. A Citizens Advisory Committee (CAC) recommended establishment of a commercial rod-and-reel fishery for lake trout. The CAC also approved the experimental use of deep water trap nets similar to those used on Lake Michigan to commercially harvest lake whitefish. Funding was obtained to build and fish nine trap nets for two 6-month assessments in LPO. Opposition to the use of trap nets surfaced in a petition with 1,820 signatures just prior to the fishery commencing. Evaluation of commercial trap nets was implemented in the fall of 2003, with 1,183 lake trout caught, tagged and released for a population estimate of 6,376 fish > 52 cm, but no lake trout were harvested. Continued opposition to the use of trap nets prompted the Department to postpone the second season of the trap net evaluation.

Introduction

Lake trout *Salvelinus namaycush* have caused increasing concerns for fishery managers in lacustrine systems in the northern Rockies due to their ability to replace native fish populations and popular sport fisheries. Donald and Alger (1993) documented the displacement of native bull trout *Salvelinus confluentus* by introduced lake trout over much of their range. More recently, Fredenberg (2002) demonstrated how lake trout expansion has had a substantial detrimental impact on bull trout populations in four Glacier National Park lakes. Illegally introduced nonnative lake trout into Yellowstone Lake in Yellowstone National Park, combined with the presence of the invasive exotic parasite *Mxyobolus cerebralis* (the causative agent of whirling disease) has resulted in a significant decline to Yellowstone cutthroat trout *Oncorhynchus clarki bouvieri* populations (Bigelow et. al. 2003) with potential ecosystem-wide consequences. Priest Lake, Idaho, is an example where lake trout increased and finally dominated the system causing the collapse of a popular kokanee *Oncorhynchus nerka* fishery and the near extirpation of native bull trout and westslope cutthroat trout *Oncorhynchus clarki lewisi* (Mauser and Ellis 1985).

Lake Pend Oreille (LPO), the largest (38,042 ha), deepest (351 m) natural lake in Idaho (Figure 1), currently supports one of the strongest adfluvial bull trout populations in the northern Rockies despite the presence of lake trout. Lake trout were introduced into LPO in the 1920s by the U. S. Fish Commission, but they have not been a significant part of the fishery until relatively recently. Bull trout redd counts in 19 tributary streams to LPO have ranged from 412 to 881 between 1983 and 2003 and the population is currently believed to be stable (Downs and Jakubowski 2002). LPO also supports a popular sport fishery for introduced trophy rainbow trout *Oncorhynchus mykiss* and kokanee.

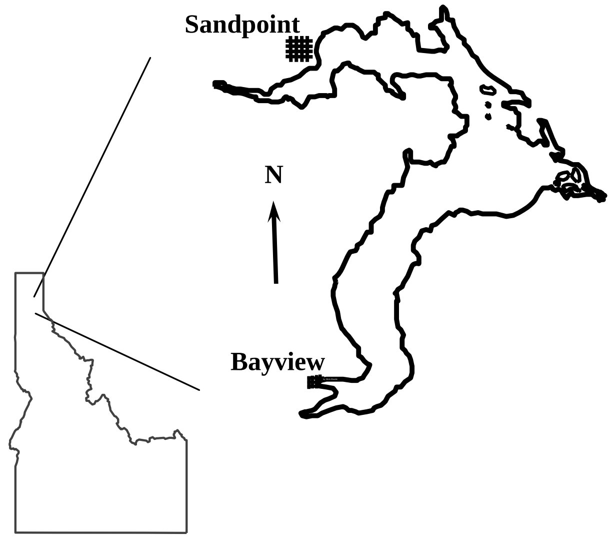

Figure 1. Lake Pend Oreille, Idaho.

Concerns that lake trout were increasing in LPO came to light in the late 1990s. Idaho Department of Fish and Game (IDFG) creel census data up through1991 (Table 1) indicated lake trout catches were rare despite their presence in the lake since the 1920s. A 1998 mark/recapture population estimate of only 1,792 lake trout > 43 cm indicated a relatively small population (Vidergar 2000). However, rainbow trout anglers were reporting increasing incidental catches of lake trout during this same time. The impact of a large flood event in 1997 resulted in a severe decline in the kokanee population and concerns over a predator induced kokanee collapse prompted significant changes to fishing regulations in 2000. The kokanee fishery was closed, the rainbow trout limit was liberalized from two fish over 50 cm to six fish any size and the limit on lake trout was removed completely. A year round creel census was conducted in 2000 to monitor predator reduction. The lake trout catch and harvest estimate during the 2000 creel was 6,025 and 4,707, respectively, despite lake trout anglers comprising only 8% of the total effort (Table 1). The difference between the population estimate of 1,792 fish in 1998 and harvest estimate of 4,700 lake trout in 2000 indicated a rapidly expanding population.

By 2002, little progress had been made toward kokanee recovery despite two years of encouraging anglers to harvest rainbow trout and lake trout. IDFG launched an intensive angler involvement program to define and implement socially acceptable means of predator reduction.

Table 1. Comparison of the 2000 angler creel survey results with past creel surveys on Lake Pend Oreille, Idaho.

	Creel Survey Year				
Parameter	**1953**	**1978**	**1985**	**1991**	**2000**
Rod hours	523,000	226,453	179,229	460,679	363,974
Angler hours	523,000	226,453	179,229	460,679	232,200
Angler days	100,000	48,470	36,446	90,000	33,140
Interviewed anglers	--	5,283	--	7,382	6,443
Lake trout					
Harvest	0	0	0	*	4,707
Percent of total	--	--	--	4%	8%
Rainbow trout					
Harvest	3,200	6,878	6,100	2,261	8,827
Percent of total	--	39%	60%	55%	86%
Bull trout					
Harvest	5,000	1,469	915	1,723	closed
Kokanee					
Harvest	1,336,000	167,640	71,275	227,140	closed

**43 fish observed in creel during 1991, but no harvest estimate was made.*

Methods

Citizens Advisory Committee Process

The Department sponsored a half-day public workshop on March 23, 2002, to discuss the LPO fishery. The objectives of the workshop were to:

- Inform the public about the declining status of the kokanee population in LPO.
- Assess community perceptions regarding why recent changes in harvest rules have not caused kokanee survival to increase.
- Identify ways to develop community support for reducing the predator population in LPO.
- Explore ideas on how the IDFG and community can build trust and communication.
- Seek community input on the desirability of convening a Citizens' Advisory Committee (CAC) to explore ways to integrate community interests with predator and kokanee population objectives.

Formation of the CAC was developed through input from the public obtained during the March Fishery Workshop. The following question was asked to workshop participants:

The Department may select representatives from your community to expand on some of the ideas that you developed today. What personal qualities,

values, or other factors would you like to see among the people that are asked to represent you on a Citizens' Advisory Committee?

Participants at the Workshop provided the following input regarding formation of the CAC: In addition to traditional stakeholders such as fishermen, fishing guides, and marina operators, the workshop participants felt that CAC members should also represent the range of interests within the broader community. This should include women, non-fishermen, community decision makers, business owners, Chamber of Commerce representatives, people that understand local economics, among others. CAC members should have strong leadership and communication skills, be open-minded, knowledgeable, inquisitive, persistent, and have the time needed to commit to the process. The workshop participants felt that CAC members should explore ways to keep the community informed.

Nine participants were selected to represent various local interests in the LPO fishery including representatives of two organized fishing clubs, two unaffiliated anglers, one charter boat captain, a local taxidermist, a marina operator, a life-long resident and a Chamber of Commerce president. Group size was limited to nine individuals to make consensus decision making more realistic.

The CAC worked under an operating Charter developed and approved by IDFG and adopted by the CAC. The Charter describes the CAC sponsors, members, budget source, background information, objectives, side-boards, products, sponsor commitments, and measures of success (CAC Final Report 2002). Seven meetings were held between May 10 and September 17, 2002. A final public workshop was held on October 23, 2002 to present recommendations and findings.

The Department asked the CAC to explore three questions:

1. How can anglers, the community, and the Department work together to reduce the predator population (i.e., rainbow and lake trout) in LPO, so we can prevent a kokanee collapse and begin recovery of the kokanee and trophy rainbow trout fishery?
2. How can the Department Panhandle Region and the LPO community communicate effectively in the future?
3. What other important issues were raised in the public workshop on March 23, 2002, that the Department could address efficiently using limited time, manpower, and funding?

The CAC developed five primary recommendations, which were distinguished as critical actions that the Department and/or local communities should consider and implement immediately. Two recommendations specifically dealt with lake trout:

1. Aggressively support and promote a "catch/keep" philosophy for rainbow and lake trout on LPO.
2. Support the establishment of a commercial fishery for lake trout on LPO.

Implementation of the CAC recommendations for lake trout and the biological and social response to implementation are the focus of the results section.

Results

Biological Actions Implemented

Commercial lake trout fishery established—As a result of the CAC recommendation, and public support at the October 23, 2002 final CAC workshop, the Idaho Fish and Game Commission approved changes to the commercial fishing rules (IDAPA 13.01.02) during their December 2002 regular meeting. The changes allowed commercial harvest of lake trout in LPO, allowed rod-and-reel as an approved commercial harvest method and allowed commercial harvesting with experimental gear such as trap nets. The CAC requested, and IDFG established, a limited entry of no more than 10 commercial licenses. An application process was established, with 13 applicants screened and 10 licenses issued in March 2003.

Commercial licenses were issued on a July 1-June 30 year. By July 1, 2003, only seven licenses were active. By July 1, 2004, only three commercial rod-and-reel lake trout licenses had been renewed. Commercial rod-and-reel anglers reported harvesting 522 lake trout and purchasing another 126 from sport anglers in the 15 months the program had been active. Sport anglers are allowed to sell up to $500 worth of lake trout annually to a commercial license holder.

Use of Trap Nets—The CAC also debated at length the experimental use of deep water trap nets as means of catching and potentially harvesting lake trout. Trap nets have been used for over 100 years in the Great Lakes to commercially harvest lake whitefish *Coregonus clupeaformis*, with lake trout also being vulnerable to this gear.

Funding for the trap net assessment ($329,400 annually for two years) was obtained through Avista Corporation, a private utility, through the Clark Fork Settlement Agreement. Harbor Fisheries, Inc., of Bailey's Harbor, Wisconsin, fished nine nets in 13 locations from October 2003 through March 2004 yielding a population estimate of 6,376 lake trout > 52 cm (Peterson and Maiolie 2004). The intent of the project was to begin to harvest lake trout once the population estimate was complete.

Social Response to Implementation Actions

Just prior to the deployment of the trap nets, a group calling themselves Citizens Against Netting Fish in Lake Pend O'Reille (CANFILPO) gathered a reported 1,820 signatures (only 1,427 were made available) on a petition against the trap netting and a letter was sent to the Idaho Governor's office, all State and Congressional representatives, as well as the Federal Energy Regulatory Commission requesting the revocation of Avista's new hydro license obtained under the Clark Fork Settlement Agreement for Cabinet Gorge and Noxon dams. CANFILPO wrote weekly letters to the editors of local and regional newspapers over an eight-month period and placed posters (Figure 2) over the information signs IDFG put out to notify anglers where trap nets were located.

The perception of public discontent resulted in changes being made to the commercial fishing rules for lake trout during the winter of 2004. Trap nets could no longer be used to harvest fish for commercial sale even though no harvest of lake trout by trap nets had occurred. A facilitated public meeting was held in February 2004 to provide information about overall fishery recovery efforts, to describe the trap net fishery results and allow public input on any topic. Of the 105 participants who registered, over 90% responded positively to a follow-up survey about the meeting information and input opportunity. CANFILPO voiced their displeasure through the survey, additional letters to the editor and comments to elected officials.

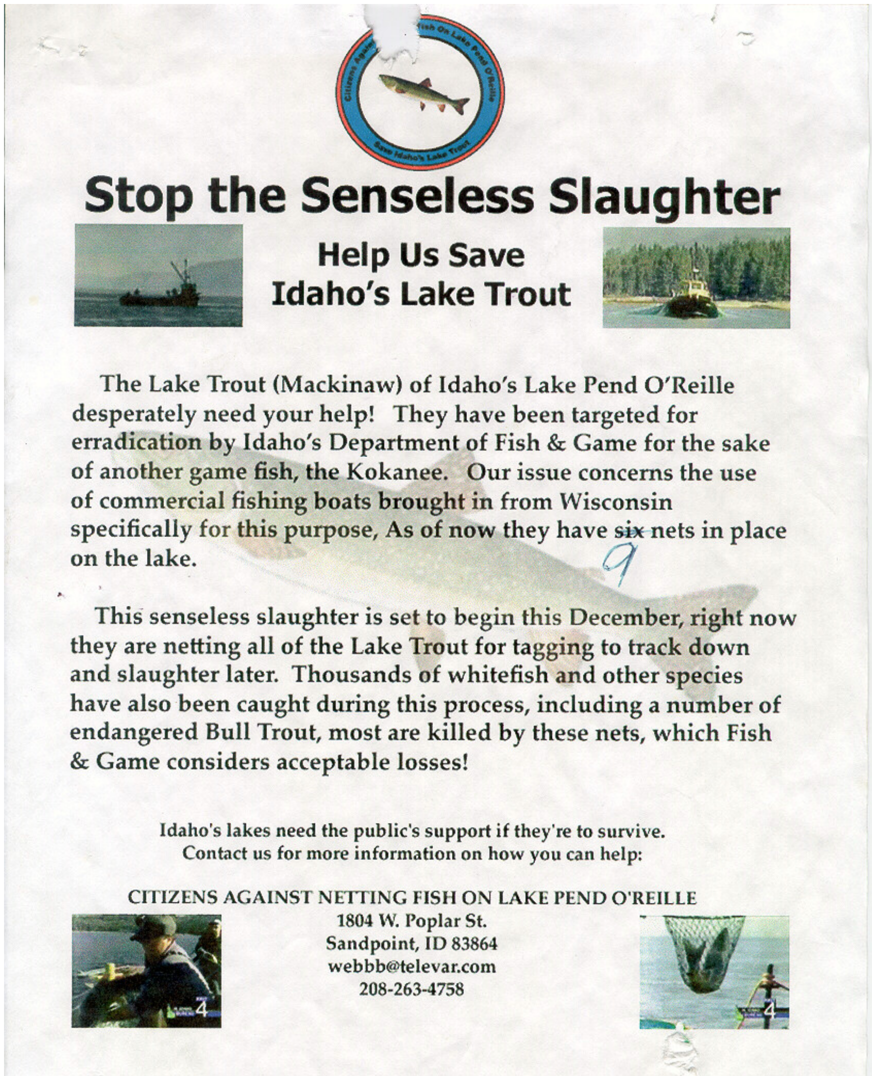

Figure 2. Poster used to protest the deep water trap net fishery for lake trout in Lake Pend Oreille, Idaho, during the winter of 2003-2004.

Continued concerns over public perceptions about the use of trap nets as well as the need to address short-term biological questions resulted in the suspension of the trap net evaluation for the winter of 2004-2005. Plans call for a resumption of the evaluation in September 2005, but trap nets will be used to redo the lake trout population estimate and gather population dynamics information on the lake whitefish population.

Emphasis during the next year will focus on evaluating how effective anglers can be at harvesting lake trout, determining lake of origin (LPO or Flathead Lake) by microchemistry analysis to better define recruitment, modeling basic population dynamics information for LPO lake trout, and conduct an angler preference survey.

Discussion

It is clear that lake trout pose a serious risk to native fish populations as well as popular sport fisheries in LPO (Panhandle Bull Trout Technical Advisory Team 1998). What is not clear is how much risk 6,400 lake trout currently pose and how the population is changing. Anglers as well as fishery managers did not react in time to keep lake trout from collapsing other fisheries. IDFG knew that predator reduction in general and consideration of removal of lake trout by trap nets would be controversial. There is now uncertainty about the level of pubic support for lake trout management actions.

The CAC process was perceived by IDFG to be a legitimate attempt to involve broad based stakeholder groups to better define what was socially acceptable in terms of predator management to recover kokanee and preserve native bull trout and a popular trophy rainbow trout fishery. Involved stakeholders did not consider CANFILPO legitimate or representative and therefore did not consider their complaints a serious threat. Of the 1,427 petition signatures made available for review, 382, or 27% were licensed anglers in 2003, suggesting many individuals signing the petition were relatively uninformed about the LPO fishery. Other anglers who supported fishery recovery efforts did not support the use of nets, so they did not counter the claims of CANFILPO. Regardless, it is clear that missing a key stakeholder group in the CAC process caused much of the effort to be ineffective.

Commercial fisheries for lake trout were a popular idea expressed at the March Workshop and further discussed and recommended by the CAC. However, the angling public is convinced that anglers can play a significant role and they are uncertain about commercial net fisheries. The results of 15 months of commercial rod-and-reel fishery harvest are not encouraging with a total of only 522 lake trout harvested and another 126 purchased from sport anglers. Lack of a suitable market for lake trout and strict Food and Drug Administration (FDA) regulations for fish handling and processing limited participation in the fishery. One commercial license holder built a FDA approved smoking facility and was marketing smoked lake trout on a limited basis.

An evaluation of angler exploitation of trap net tagged lake trout during the annual spring fishing derby indicated a 12% exploitation rate during a time frame when approximately half of the annual angling effort occurs. Even if this value is increased to account for non-reporting bias, it suggests controlling lake trout through sport fishing alone may be difficult. Healey (1978) indicated that lake trout could sustain a combined annual mortality rate (natural mortality and exploitation) of about 50% and still remain viable. IDFG will be evaluating angler harvest effectiveness over the next year by shifting some of the funding from the trap net evaluation to derbies or other incentive programs and measuring harvested fish against the trap net population estimate. Another trap net population estimate in 2005-2006 will provide an additional measure of angler harvest potential.

The first season of the trap net evaluation demonstrated the usefulness of commercial gear for research, but large trap nets alone may not be a suitable way to suppress the lake trout population (Peterson and Maiolie 2004). However, it may be possible to improve trap net effectiveness in LPO. Trap net fishing location and timing were modified in 2003-2004 to address sport fishery concerns. Future plans would evaluate times of the year when catch rates for trap nets were higher (September and April) and suspended nets would be fished in an attempt to sample the steep shorelines of LPO.

Lake trout have not been a preferred species in LPO, so it was surprising to see the reaction generated by CANFILPO. Lake trout have been managed against in LPO with liberal bag limits since 1992. Past creel census information indicated that participation in the lake trout fishery was minimal, with the vast majority of anglers preferring kokanee and trophy rainbow trout (Table 1). The relatively recent increase in lake trout, combined with regulation changes to restore the kokanee population, have given the lake trout fishery a boost. Some consumptive oriented anglers have shifted from kokanee to lake trout due to the kokanee fishery closure and competitive trophy anglers have done better in recent derbies focusing on lake trout instead of rainbow trout. Still, a limited creel census during the spring derby in 2004 indicated that only 12% of the anglers were fishing for lake trout despite better catch rates, bigger fish and equal prize money to rainbow trout. An independently conducted angler preference survey is needed to assess what role the lake trout fishery plays in relation to native fisheries for bull trout and cutthroat trout and popular sport fisheries for kokanee and trophy rainbow trout. It will be impossible to please everyone.

The aggressive action taken by IDFG to address the lake trout threat in LPO was viewed as necessary by the apparent rapid increase in lake trout indicated by the 2000 creel census. Fortunately in the near term, the trap net evaluation demonstrated that lake trout were not as abundant as feared, but still higher than 1998. There are still important unanswered biological questions to pursue, including quantifying recruitment, identifying recruitment sources (natural from LPO or downstream drift from Flathead Lake), the predatory impact of lake trout on other species, and whether human induced mortality on lake trout can be elevated to a point where lake trout numbers can be controlled. Just as important, social concerns about lake trout control must be addressed before we can move forward with fishery recovery efforts.

Acknowledgements

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Balancing Bonneville Cutthroat Trout with Non-Native Salmonids in Great Basin National Park

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ABSTRACT— Bonneville cutthroat trout, the only native trout in Great Basin National Park, have been reintroduced into several streams in and near the park following their extirpation at the beginning of the century. At the same time, Great Basin NP has emphasized the availability of a recreational fishery for non-native salmonids in other park streams, using tools such as the park newspaper, resource management newsletter, website, and an interagency brochure distributed throughout the area. The response to this two-pronged approach has largely been positive, with the greatest amount of conflict from the state, which has a different management philosophy. The cessation of non-native stocking when the park was established in 1986 caused some locals to mourn the loss of the big trophy fish they remember catching in previous years. Population surveys reveal that size of brown trout has indeed decreased in some streams while fish abundance has increased. The park has responded to these concerns using data that show that the density of Bonneville cutthroat trout is greater than that of non-native salmonids. Once Bonneville cutthroat trout populations have stabilized in the next 5-10 years, it is expected that these populations will provide a popular and unique fishery.

Introduction

When Great Basin National Park was established in 1986, the enabling legislation specifically stated that the Secretary of the Interior "shall permit fishing on lands and waters under his jurisdiction within the park." At that time, it was believed that all fish in park streams were non-native salmonids, despite the east side of the park being located in the Bonneville Basin (Figure 1), the native range of the Bonneville cutthroat trout (*Oncorhynchus clarki utah*) (BCT). National Park Service (NPS) management policies direct that the NPS will maintain natural ecosystems by "preserving and restoring the natural abundances, diversities, dynamics, distributions, habitats, and behaviors of native plant and animal populations and the communities and ecosystems in which they occur (NPS Management Policies 2000)." In order to find a balance between fishing opportunities and preservation of native species in its fisheries program, the park has focused on two main issues: reintroduction of Bonneville cutthroat trout back into its native range and recreational fishing for the visiting public.

BCT Background

BCT have experienced major declines throughout their range and were once thought to be extirpated from Great Basin NP. Endemic to the Bonneville Basin, this subspecies of cutthroat once flourished in Lake Bonneville. At its highest extent, Lake Bonneville included the Snake Valley arm that reached to the streams on the east side of the southern Snake Range, which are now mostly encompassed within the park. The Snake Valley population of BCT became

Figure 1. Former extent of Lake Bonneville.

isolated from the rest of the basin beginning about 8,000 years ago, when the lake started shrinking (Behnke 1976). Such reproductive isolation allowed sufficient time for considerable genetic divergence, and scientists suggest this population should be considered a unique race or group (Behnke 1988, 1992; Shiozawa et al. 1993) which is called the Western BCT (USDA Forest Service 1996).

The large-scale extirpation of Western BCT was due largely to habitat alterations following human settlement of the area and the indiscriminate and widespread stocking of non-native salmonids (brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), Lahontan cutthroat trout (*Oncorhyncus clarki henshawi*) and Yellowstone cutthroat trout (*Oncorhyncus clarki bouvieri*)). The presence of non-native fish continues to be a threat to efforts for recovery of BCT. Habitat alterations such as livestock grazing have ceased, with all livestock grazing permits on the east side of the park retired by the Conservation Fund in 2000. Logging that was undertaken when the land was administered by the US Forest Service has since ceased, but its effects are still evident, particularly with the network of logging roads.

In 1998, an interagency team composed of the Humboldt-Toiyabe National Forest (HTNF), Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (FWS) and Nevada Department of Wildlife (NDOW) convened at Great Basin NP and developed a proposed action for the reintroduction of BCT to historic range within and adjacent to the park. A BCT Reintroduction Plan and accompanying Environmental Assessment were completed and signed by the Regional Director on November 10, 1999. The primary objective of the plan was to reestablish viable populations of western BCT, the only native salmonid to Great Basin NP.

The park's effort was not isolated, and in 2000, a range-wide Conservation Agreement was finalized and signed by the wildlife agencies of the states of Utah, Wyoming, Idaho, and Nevada, along with the HTNF, BLM, FWS, NPS, and Utah Reclamation Mitigation and Conservation Commission, with support from Trout Unlimited and other organizations. This range-wide agreement coordinated BCT restoration efforts to prevent its listing under the Endangered Species Act.

Habitat

In 2000, there were an estimated 30 miles of historic but vacant Western BCT stream habitat within the park and 56.5 miles, some of which was occupied by Western BCT, on the HTNF. This gives a total estimate of 86.5 miles of historical BCT habitat within the Snake Range in Nevada. Based on the estimate that historically 90 percent of these stream miles contained Western BCT, about 94 percent of the Western BCT populations had been extirpated (USDA Forest Service 1996).

Objectives

The objectives of Great Basin National Park's 1999 Bonneville Cutthroat Trout Reintroduction and Recreational Fisheries Management Plan included: 1) reintroduce viable populations of BCT with enough separate populations so that catastrophic events would not lead to the loss of all populations within the park; 2) over time evaluate and develop the sport fishery potential of this unique species for the enjoyment of current and future generations; 3) increase the knowledge of fishing and accessibility to Baker and Lehman Creeks.

Methods

Recreational Fishing

In order to increase the knowledge of fishing in the park, a number of articles were written and distributed through various media. Volunteers were recruited for population surveys, thinning projects, and trail building to increase access to popular fishing areas. Fisheries resources were included to a greater degree in park planning.

BCT Reintroduction

Reintroducing BCT into park streams required a lengthy and time-intensive process, including 1) baseline surveys, 2) pre-treatment monitoring, 3) treatment, 4) post-treatment effectiveness monitoring, 5) reintroduction of BCT, and 6) post-reintroduction effectiveness monitoring.

Baseline surveys were completed first to determine if the stream was suitable for BCT reintroduction. Physical habitat surveys used the EPA's Rapid Bioassessment of Creeks and Small Rivers protocols (1999), including substrate size, riparian cover, mapping selected reaches, and noting habitat characteristics and condition. Amphibian surveys searched for adults, tadpoles, and egg masses using standard North American Amphibian Monitoring Protocols. Water quality measurements included temperature, dissolved oxygen, conductivity, pH, turbidity and flow, along with taking a water sample that was analyzed in the park's water quality lab for nitrates, phosphates, alkalinity, hardness, sulfates and silica. Macroinvertebrate surveys followed the EPA's Rapid Bioassessment of Creeks and Small Rivers protocols and included both riffle only-quantitative and multi-habitat-qualitative surveys. All samples were sent to the Utah State University Buglab for analysis. Mollusk surveys were also conducted and sent to the Buglab for identification. Fish surveys found the last fish in each selected stream so that the treatment could be focused and have less impact on the rest of the stream ecosystem.

Baseline surveys showed that Mill Creek (Figure 2) contained a pure BCT population, previously identified as a hybrid population, but confirmed by two genetics labs as pure. The known BCT population in Pine and Ridge Creeks, outside of the historic range, were also confirmed to be a pure population.

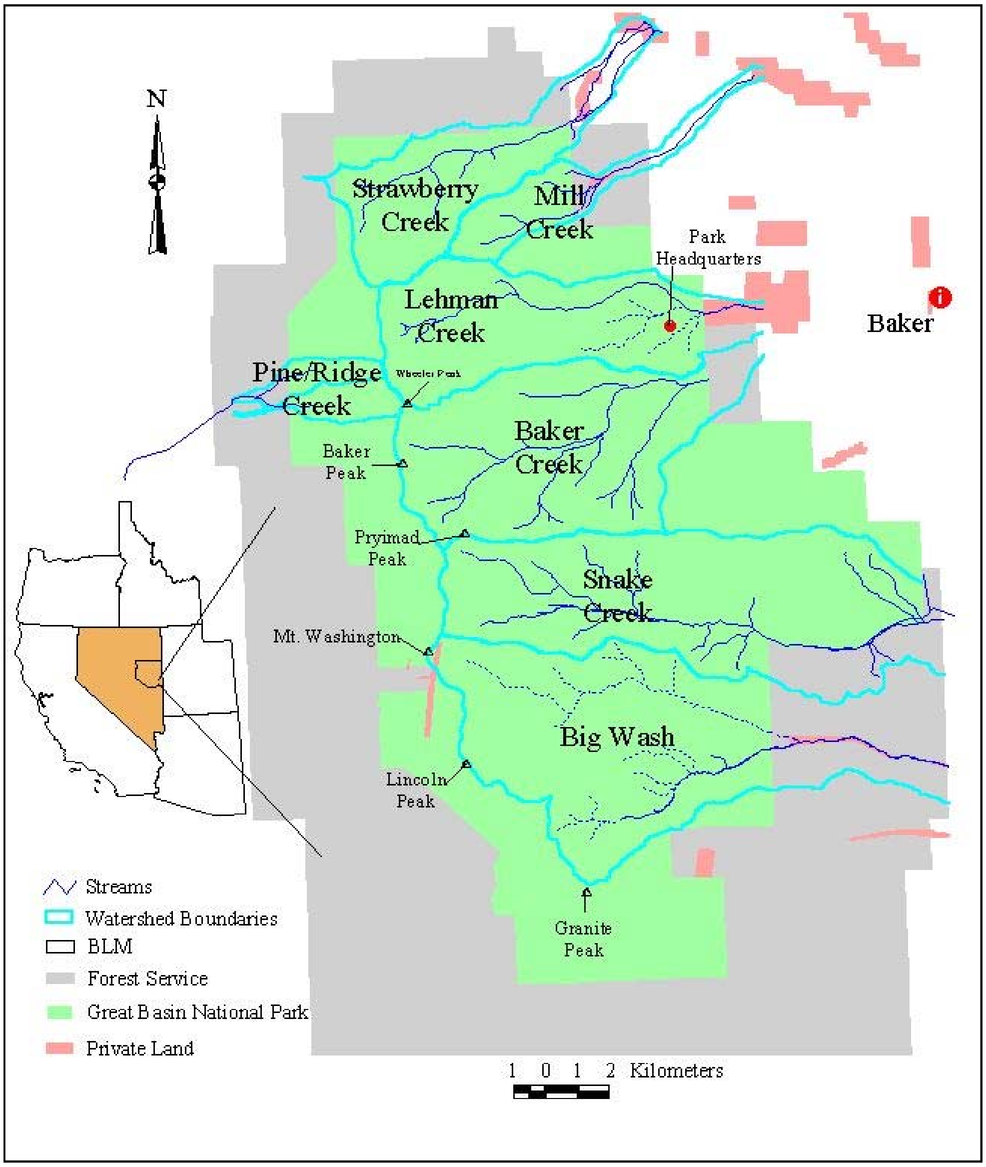

Figure 2. Map of Great Basin National Park streams.

Additional streams were selected for BCT reintroduction: Strawberry, South Fork Big Wash, Upper Snake, and South Fork Baker Creeks. These streams were studied more intensely during the pre-treatment monitoring stage, which repeated water quality, macroinvertebrate, mollusk, and amphibian surveys.

Treatments consisted of electrofishing (South Fork Baker) or using a chemical pesticide, either rotenone (Strawberry Creek) or antimycin (Upper Snake Creek), to kill all the non-native fish in the selected area. Creeks that were chemically treated were divided into sections and had drip-stations applying the chemical at a measured rate. Small seeps and springs along the stream were treated by applicators using backpack sprayers. Each creek had the equivalent of two treatments during the course of a week to ensure that all non-native fish were killed. South Fork Big Wash required no treatment due to a flash flood in 1953 that removed all fish from the reintroduction site.

Post-treatment surveys began one week after the treatment and were repeated at one-month, nine-months, and one-year post treatment. These surveys included water quality, mollusk, and macroinvertebrate analyses. Once the post-treatment surveys indicated that macroinvertebrate population and diversity numbers had reached 75% of pre-treatment levels, BCT were reintroduced into the stream in the fall.

To determine the success of the BCT reintroduction, post-reintroduction surveys were done, including annual population surveys of BCT using standard three-pass depletion methods. Distribution surveys include spot shocking the streams to determine the rate of BCT movement from the reintroduction sites.

Results

Recreational Fishing

Focus on recreational fishing was accomplished by articles in the park newspaper, available to all park visitors; fishing information on the park website (www.nps.gov/GRBA); and the Snake Range Recreational Fishing brochure (Figure 3), a full-color brochure produced in cooperation with NDOW, HNF, and BLM. This brochure is posted at area kiosks and distributed by local agencies and businesses. Additional media coverage has included interviews for PBS stations, radio interviews, and an article in the International National Park Magazine. These efforts have helped the park develop a strong volunteer base, with over 1600 volunteer hours contributed from 2000-2003. Access to recreational fishing areas was increased by Trout Unlimited volunteers who conducted riparian enhancement activities such as thinning along an overgrown section of Baker Creek. In addition, a trail was constructed from Baker Creek campground to Grey Cliffs campground, with fishing areas next to Baker Creek. Recreational fishing has also been included in park planning to a greater degree: the park’s new fire plan includes consideration for fishery resources; best

Figure 3. Cover of Snake Range Recreational Fishing brochure

management practices are incorporated for culverts and road grading to minimize sediments affecting spawning areas; and post-fire rehabilitation has been conducted, particularly in the South Fork of Big Wash watershed, to minimize erosion into the stream.

Volunteers have been essential to completing population surveys on recreational fishing streams within the park. The most popular areas for angling are Baker, Lehman, and Snake Creeks, the largest creeks in the park. All three of these streams were stocked on a regular basis from 1924-1986, with at least 400,000 fish stocked during this time period. Stocking ceased with the establishment of the park in 1986, and some anglers complained that the fisheries was declining. The park began completing its own fish surveys in 1999 after the Southern Nevada Chapter of Trout Unlimited purchased two electrofishers. Since then the park has conducted more population surveys than had been done during the 62 years fish had been stocked in the stream.

The population surveys show two trends: the number of fish in these three main creeks is increasing, but the size of brown trout (the most common trophy fish of the area) is decreasing (Table 1). It must be noted that NPS surveys followed the 3 pass, 100 m depletion method, while the NDOW surveys used the 1 pass, 100 ft method. Although these different methods are certainly responsible for some of the difference in number of fish/mile estimated, some of the NPS surveys estimated double the number of fish/mile as previous surveys.

Table 1. Number of fish/mile and lengths of fish in selected reaches for Lehman, Baker, and Snake Creeks.

		Average Fork Lengths (mm)					
Year	**Estimated Fish/mile**	**Brook**	**Brown**	**Rainbow**	**YOY**	**Method**	**Survey by**
LEHMAN CREEK FROM PARK BOUNDARY TO LEHMAN CREEK CG							
2003	2528	137	190	162	65	3 pass, 100 m	NPS
1990	774*	149	230	134		1 pass, 600 ft	NDOW
1984**	1373*					1 pass, 100 ft	NDOW
1952	163					not specified	NV Fish & Game
BAKER CREEK FROM GREY CLIFF NARROWS TO TRAILHEAD							
2003	2527	156	157	165	77	3 pass, 100 m	NPS
1990	1088*	140	163	154		1 pass, 500 ft	NDOW
SNAKE CREEK FROM REARING STATION TO PIEPELINE OUTLET							
2002	1545		136			3 pass, 100 m	NPS
1990	905*		147			1 pass, 680 ft	NDOW
2000	2495	109	138		54	3 pass, 100 m	NPS
1984	1003		204	213		1 pass, 100 ft	NDOW
1960	501***					unknown	NDOW

** Estimates include recorded misses*

***Pop survey done 17 days after a plant of 749 fish; 41% of fish caught were planted based on fin wear characteristics*

****Estimate includes 26 smooth sculpin/mile*

Although most anglers now fish for non-native species, when the reintroduced BCT become established, estimated in approximately 5-10 years, anglers should have an excellent fishing opportunity. Since BCT have evolved in these mountain streams, they have been able to adapt to food and environmental conditions better than non-natives, and can grow larger. The density of BCT in Mill Creek is 66 fish/100m2, which is more than the density of brown, brook, and rainbow trout combined in Lehman Creek (54 fish/100 m^2) or Baker Creek (62 fish/100 m^2) (Figure 4).

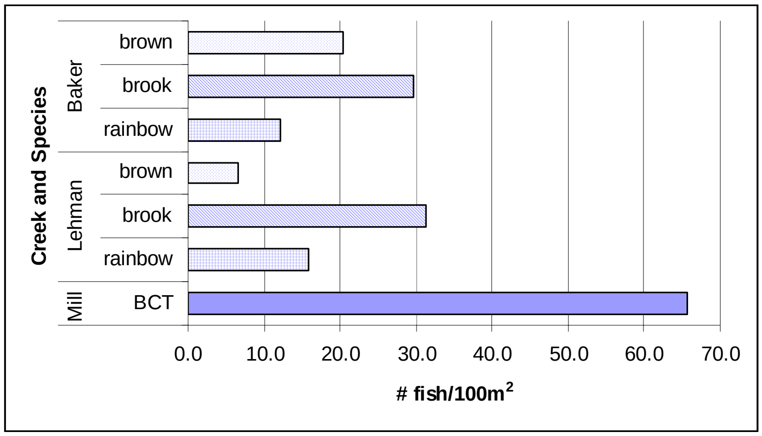

Figure 4. Density of trout species in selected creeks. v

Bonneville cutthroat trout

Currently BCT reside in 17 miles of streams in and near the park, and they have quickly adapted to their new habitats. Spawning success was evident in both Strawberry and South Fork Big Wash creeks the year following reintroduction. Fifty-six BCT were moved from diminutive Mill Creek (Figure 5) to South Fork Big Wash, and in just two years had grown 60% longer (Figure 6), with the largest bigger than any BCT found in Mill Creek.

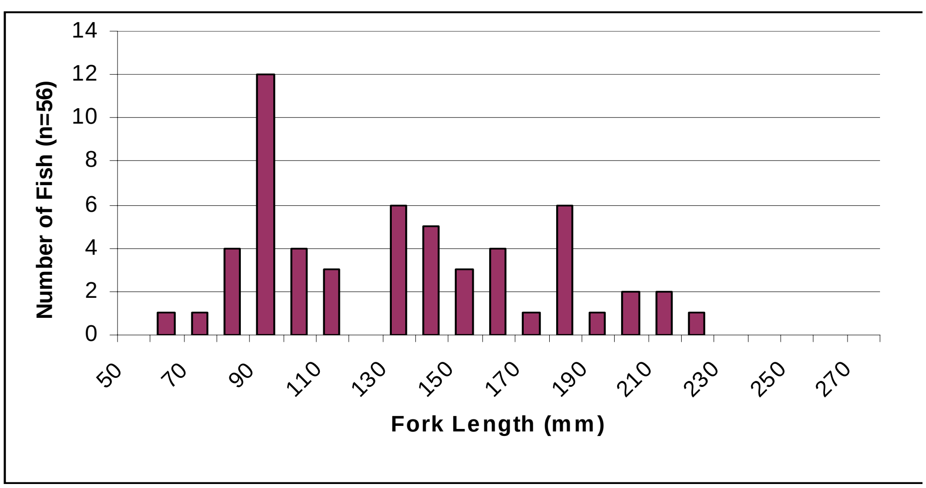

Figure 5. Length of BCT moved from Mill Creek to South Fork Big Wash in July 2000.

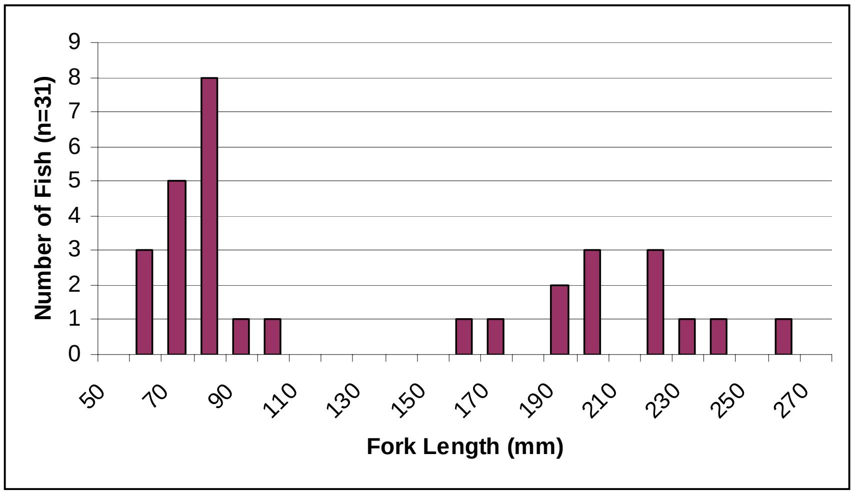

Figure 6. Length of BCT in South Fork Big Wash in August 2002.

The timeline for this project was relatively short, given the nature of the funding. Therefore, a huge emphasis was placed on macroinvertebrates as indicators of stream health. Macroinvertebrates were collected in the spring and fall for two years prior to treatment in Strawberry Creek and three years prior to treatment in Snake Creek. They were also collected one-week prior to treatment, and following treatment at one week, one month, nine months, and one year. The recovery rate of macroinvertebrates to rotenone and antimycin was one of the goals of the project in order to provide information to fisheries managers considering indicate that following the rotenone treatment on Strawberry Creek, overall macroinvertebrate numbers declined 85%, while EPT numbers declined 99%. The antimycin treatment on Snake Creek had a smaller effect on macroinvertebrates, causing their numbers to decline 61% overall, and 54% for EPT taxa. (Figure 7). Macroinvertebrate diversity was severely impacted by rotenone, with 95% decline in taxa one month after treatment in Strawberry Creek, compared to 29% decline in Snake Creek.

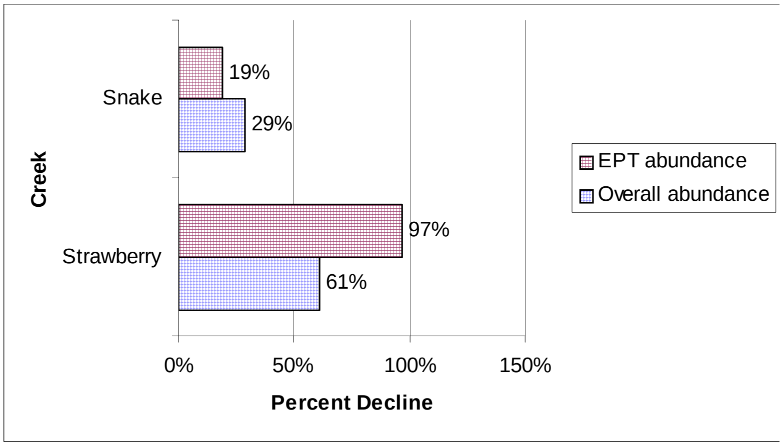

Figure 7. Decline of macroinvertebrate abundance one month following the antimycin treatment on Snake Creek and the rotenone treatment on Strawberry Creek.

Discussion

The park believes that the BCT reintroduction project has not only been one of the most successful park projects but an outstanding example of NPS management. The task of restoring an extirpated species was found to be complex and required persistence and dedication to achieve that goal. BCT have not only been restored to previous habitat and currently occupy 17 miles of creek in and near the park, but due to these efforts, this project precluded the need for listing the BCT as threatened under the Endangered Species Act. This project is an example of proactive management in fulfilling the NPS mission. Park staff have made great efforts to share the results of the BCT project with the public with a mostly positive response. Nonetheless, a project this large is bound to have difficulties. Overcoming these difficulties and learning lessons from them has helped with other projects and may help other parks and agencies that are attempting to do similar fisheries restoration projects.

Lessons Learned

One of the biggest lessons that the park learned is that fish are highly political. NDOW created numerous hurdles for the park by questioning projects and blocking progress, especially for the Snake Creek treatment, Johnson Lake treatment, and moving BCT into Strawberry, South Fork of Big Wash and Snake Creeks. By using the best available science, the park addressed all these issues and worked cooperatively. These issues mainly stemmed by NDOW's reluctance to recognize that the Great Basin NP enabling legislation placed the management of both the habitat and the fish and wildlife within its boundaries under the direction of the Secretary of Interior.

Adaptive management has played an extremely important role throughout the project. One example is when BCT were found in Mill Creek, it suddenly became unnecessary to complete a treatment on that creek, and Mill Creek became a donor population. This saved the last relict population within the historic range of BCT in Great Basin NP. This discovery helped to speed up reintroduction efforts given the inability of NDOW to meet its commitment to supply fish for the project. When the park learned from a local that Johnson Lake spilled over to Snake Creek during runoff in high snow years, the park listened and determined that the lake would have to be treated to protect the BCT population below.

Streamside incubators were used to help hasten the reintroduction process. Trout Unlimited provided the first incubators and the expertise of how to use them. Park staff monitored Mill Creek intensely to determine when BCT were spawning, since that information had not been obtained previously. Eggs and milt were gathered from spawning BCT, mixed together to fertilize the eggs, then transported on ice to the incubators in Strawberry Creek. Although the eggs started out well, low water flows mixed with high sedimentation caused fungus to grow out of control on the eggs, and none survived. Larger wild populations, higher water flows, less turbidity, and a more easily accessible site would all help to make the incubators work better. Although the use of streamside incubators was not successful, the information gained about the spawning BCT was of great value.

From the beginning of the project, the park knew that it could not follow the timetable used by NDOW for their fisheries restoration projects, which is generally waiting 5-10 years after a stream has been treated to reintroduce BCT.

Therefore resource managers decided to limit the treatment reach through intensive pre-treatment surveys that determine fish distribution and to monitor the macroinvertebrate population intensely to find out just how soon BCT could be reintroduced into the stream and have a sufficient food base. This information, coupled with the comparison of how streams respond to both rotenone and antimycin treatments, is of great interest to fisheries personnel for better managing their streams. Since the park has shared the preliminary results of how fast macroinvertebrates return, NDOW has changed their timetable, and reintroduced BCT into Big Wash Creek only two years after treatment.

The Future

The park looks forward to watching park BCT populations develop into self-sustaining populations. The BCT will then provide a popular and unique fishing experience. The park will periodically reassess its fisheries program to determine if it is achieving the goals of the fishery management plan. Finally, by carrying out this project, the park has helped to achieve the NPS mission to preserve the native fauna for future generations.

Acknowledgements

We thank the many field technicians and volunteers who assisted with the Bonneville cutthroat trout reintroduction project. This project was supported by the National Park Service and Trout Unlimited.

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Recovery and Management of Native and Non-Native Fish Populations in the Bear Butte Creek Watershed in the Black Hills of South Dakota Following Historic and Recent Mining Activity

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ABSTRACT—When Lt. R.I. Dodge and the U.S. Army conducted a scientific exploration of the Black Hills of Dakota Territory in 1876; the only fish reported were suckers and dace. Since the introduction of trout in the 1880's, wild brook (*Salvelinus fontinalis*), brown (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) populations have become established in the streams of the Black Hills. Today, trout anglers fish about 500,000 days a year in the Black Hills. Since 1992, South Dakota Department of Game, Fish and Parks has monitored the longnose dace (*Rhinichthys cataractae*), mountain sucker (*Catostomus platyrhynchus*), and brook trout populations within the Bear Butte Creek watershed. Mining activity within the Bear Butte Creek watershed began with the gold rush of 1876 and concluded in 1998 when the Gilt Edge Mine ceased operation and was designated as a Superfund Site by the EPA. There has been a steady recovery of the native and non-native fish populations in Bear Butte downstream from the Gilt Edge Mine since 1998. Currently the State of South Dakota and the EPA are developing remedial objectives for the Gilt-Edge Mine that includes objectives to insure the future existence of native and non-native species within this watershed. Questions that still need to be answered relate to the suitability of the Bear Butte Creek watershed as a refuge for Black Hills native fish species and the acceptability of native fish species management in this watershed by recreational anglers.

Introduction

In 1995, South Dakota Department of Game, Fish and Parks (SDGFP) mailed 3,448 questionnaires to anglers who had been interviewed by creel clerks the previous year as part of a year-long Black Hills angler use and preference study (Erickson and Galinat, unpublished report). A total of 2,209 (68%) anglers returned a completed questionnaire. After being informed that trout were not native to the Black Hills, anglers were asked if SDGFP should manage for native fish in the Black Hills. Although a small percentage of the respondents failed to answer the question (6%), 29% of the anglers responded "yes", 21% responded "no", and a high percentage (44%) had no opinion.

Currently, none of the streams in the Black Hills of South Dakota are managed explicitly for native fish, nor have quantifiable objectives been developed for the native fish populations. The purpose of this study was to determine the status of the fish populations in the Bear Butte Creek watershed and evaluate the potential for SDGFP to manage this watershed for native and non-native fish.

Watershed Description

Bear Butte Creek is located in the Northern Black Hills of Western South Dakota. It is an extension of the Middle Rockies Ecoregion and shares with it a montane climate, hydrography, and land use pattern (Bryce et al. 1998). Ranching, woodland grazing, logging, recreation, and mining are common activities within the watershed. Bear Butte Creek originates in the granitic core of the Black Hills at elevation of approximately 6,000 feet. It flows over metamorphized areas before, losing all its flow to sink holes in the limestone that surround the Black Hills.

Mining played a significant role within the Bear Butte Creek watershed. The entire Black Hills area was once called the richest 100 square miles on earth for its geologic resources. Small mining claims intersect nearly the entire stream coarse before it enters the historic mining town of Galena and the Galena Mining District. Approximately 8 km below the headwaters, Bear Butte Creek is joined by Strawberry Creek. As early as 1940, extensive mine drainage was documented in Bear Butte Creek below Strawberry Creek that drained the Gilt Edge Mining District. Common mining practices at the time often led to mine wastes entering nearby waterways. This was the case in the lower Bear Butte watershed where stream disposal of tailings had widespread public approval in an effort to plug the limestone sinkholes and increase the availability of water to downstream users. The mine drainage from the Gilt Edge Mine contained effluent from an oil flotation mill, runoff from cyanide tailings dumps and water pumped from the underground mine. Discharge of mine wastes continued until the mill closed in 1941. Subsequently, Bear Butte Creek from the headwaters to the Lawrence County line was severely impaired by heavy metals and elevated total suspended solids from tailings left along Strawberry Creek after mining (SDDENR 2004).

In 1986 Brohm Mining Corporation received a surface mining permit to heap leach ore on the Gilt Edge properties. The mine permit contained provisions to remove or stabilize the remaining tailing in Strawberry Creek. Brohm Mining Corporation completed the cleanup of the historic, acid generating Gilt Edge Tailings along Strawberry Creek in 1995. This resulted in a significant improvement to the watershed (SDDENR 1995). Surface water quality assessments for water years 1996-2001 and current assessments along the entire monitored length of Bear Butte Creek have fully supported all assigned beneficial uses (SDDENR 2004). However, periodic releases of solutions containing cyanide, low pH water or metals have exceeded SD water quality standards in both Strawberry and Bear Butte Creeks. The State took over remedial activities in 1998 when Brohm Mining Corporation filed bankruptcy and mining at the Gilt Edge properties ceased. The mine site has been added to the National Priorities List for releases of cadmium, cobalt, copper, manganese, lead and zinc that have been documented in Strawberry Creek. The EPA is still considering final alternatives for the site, and currently only a few remaining workers operate the water treatment system (USEPA 2004).

Methods

Since 1992, the SDGFP has monitored fish populations by conducting multi-pass electrofishing surveys on all of the perennial streams in the Black Hills. This information is stored in a centralized database and is integrated with a GIS coverage of 360 electrofishing sites that have been established in the Black Hills. Block nets are placed at the top and bottom of the 100m long electrofishing sites to prevent fish from moving into or out of the site. Standard operating procedures require a minimum of three electrofishing passes be completed with backpack electrofishers. Fish from each pass are kept in separate holding cages. Total length (mm) and weight (g) are recorded from all trout and for a minimum of 100 individuals for all other species. Wetted stream width is measured to the nearest 0.1 meters at 11 equally spaced transects and the mean width and stream length were used to calculate fish productivity estimates on a per area basis.

Six electrofishing sites were established in the early 1990's to monitor the fish populations downstream from the Gilt Edge Mine (Figure 1). The electrofishing site immediately upstream of the confluence with Strawberry Creek was established to represent reference conditions since there is no runoff to Bear Butte from the Gilt Edge Mine upstream of Strawberry Creek. The electrofishing site immediately downstream of Strawberry Creek was selected since it is the most upstream section of Bear Butte Creek that is exposed to water discharged from the Gilt Edge Mine. Electrofishing sites were also established immediately above and below the confluence with Ruby gulch which has been used as the repository for spent ore and waste rock. Two additional electrofishing sites were established approximately 2 km downstream of the Gilt Edge Mine at the historic Double Rainbow Mine. These sites bracket an abandoned mine that produces "yellow boy" precipitate from relic tailings. Bear Butte Creek becomes an intermittent stream approximately 1.5 km downstream of the Double Rainbow Mine when it crosses a limestone outcrop.

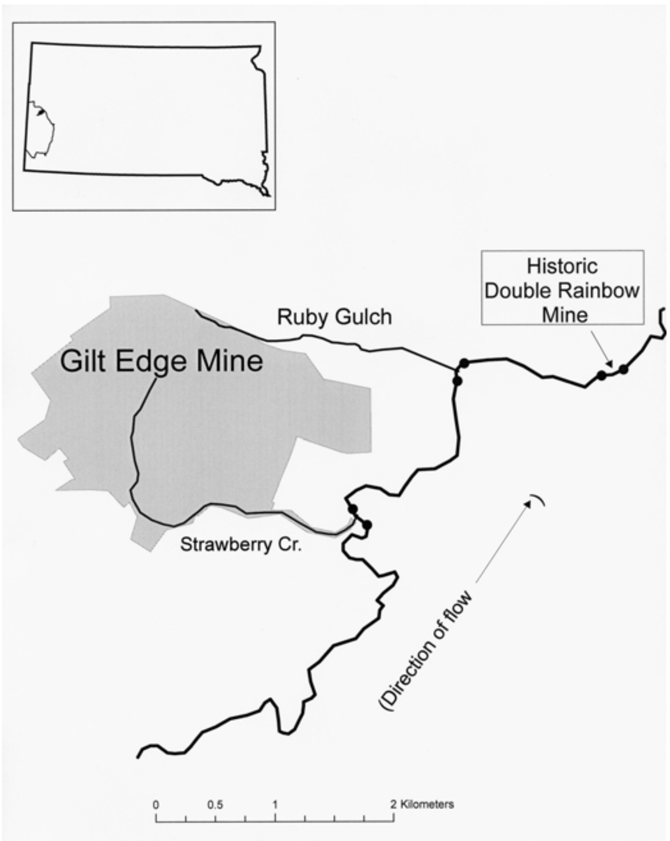

Figure 1. Location of six electrofishing sites on Bear Butte Creek that were selected to monitor the fish populations downstream of the Gilt Edge Mine EPA Superfund site in the Black Hills of South Dakota.

The minimum number of electrofishing passes was increased to four in 1998, when the Gilt Edge Mine was officially designated as "Superfund" Site by the EPA. The number of passes was increased so as to decrease the size of the error term associated with the population estimates. Population density estimates were calculated using Burnham's maximum-likelihood estimate for removal depletion surveys (Platts et al. 1983).

Results

Three hundred sixty fish population monitoring sites have been established in the Black Hills. A total of 858 multi-pass electrofishing surveys have been conducted by SDGFP and several consulting firms since 1992. The majority of the perennial streams in the Black Hill capable of supporting fish are found in the northern and eastern portions of the Black Hills (Figure 2). Mountain suckers were collected at 75 sites and longnose dace were collected at 147 sites. Both of these species have been collected from the majority of the electrofishing sites within the Bear Butte Creek watershed (Figure 2). Brook trout have been collected at 147 sites and are more widespread in the Black Hills than the brown trout. Brown trout have not been documented within the portion of the Bear Butte Creek watershed that is within the Black Hills Trout Management Area.

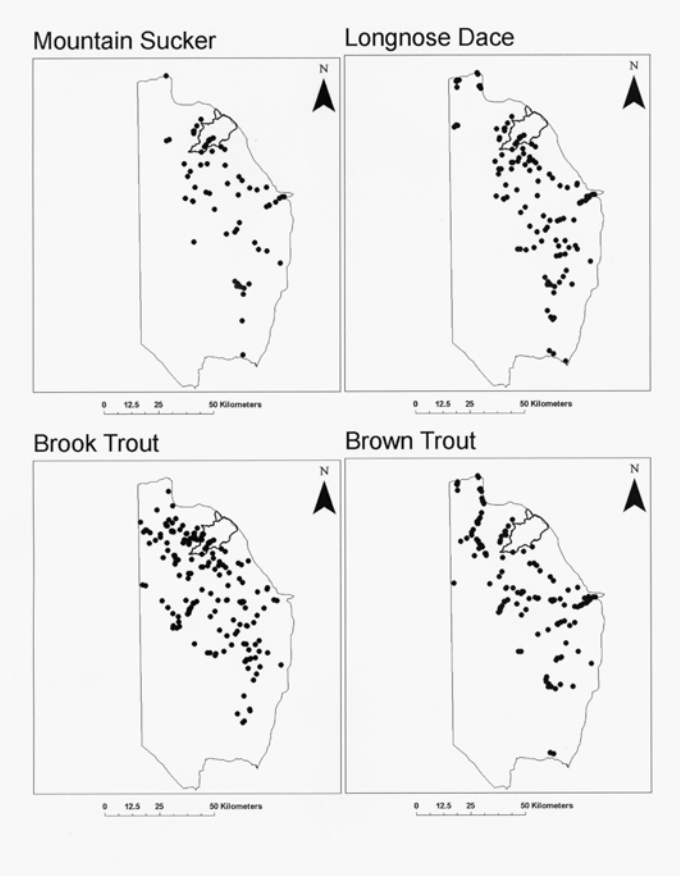

Figure 2. Distribution of mountain suckers, longnose dace, brook trout, and brown trout within the Black Hills Trout Management Area of South Dakota. Fish population surveys were conducted by SDGFP (1992-2003). The boundary for the Bear Butte Creek watershed is identified for each map.

The population density of longnose dace, brook trout and mountain sucker were lower in 1998 than in 1997 (Figure 3). Longnose dace were not sampled from Bear Butte Creek downstream of the confluence with Strawberry Creek in 1998. However, the estimated density of longnose dace upstream of the confluence with Strawberry Creek exceeded 700 fish per 100 m of stream. Since 1998, the density of longnose dace in Bear Butte Creek downstream from Strawberry Creek has increased. The density of brook trout in Bear Butte Creek downstream from the confluence with Strawberry Creek has increased since 1998. Since 2000, the density of brook trout in Bear Butte Creek downstream from Strawberry Creek has been greater than the density of brook trout upstream from Strawberry Creek. In recent years the density of mountain sucker in Bear Butte Creek downstream from Strawberry Creek has been similar to the density of mountain sucker upstream from the confluence with Strawberry Creek.

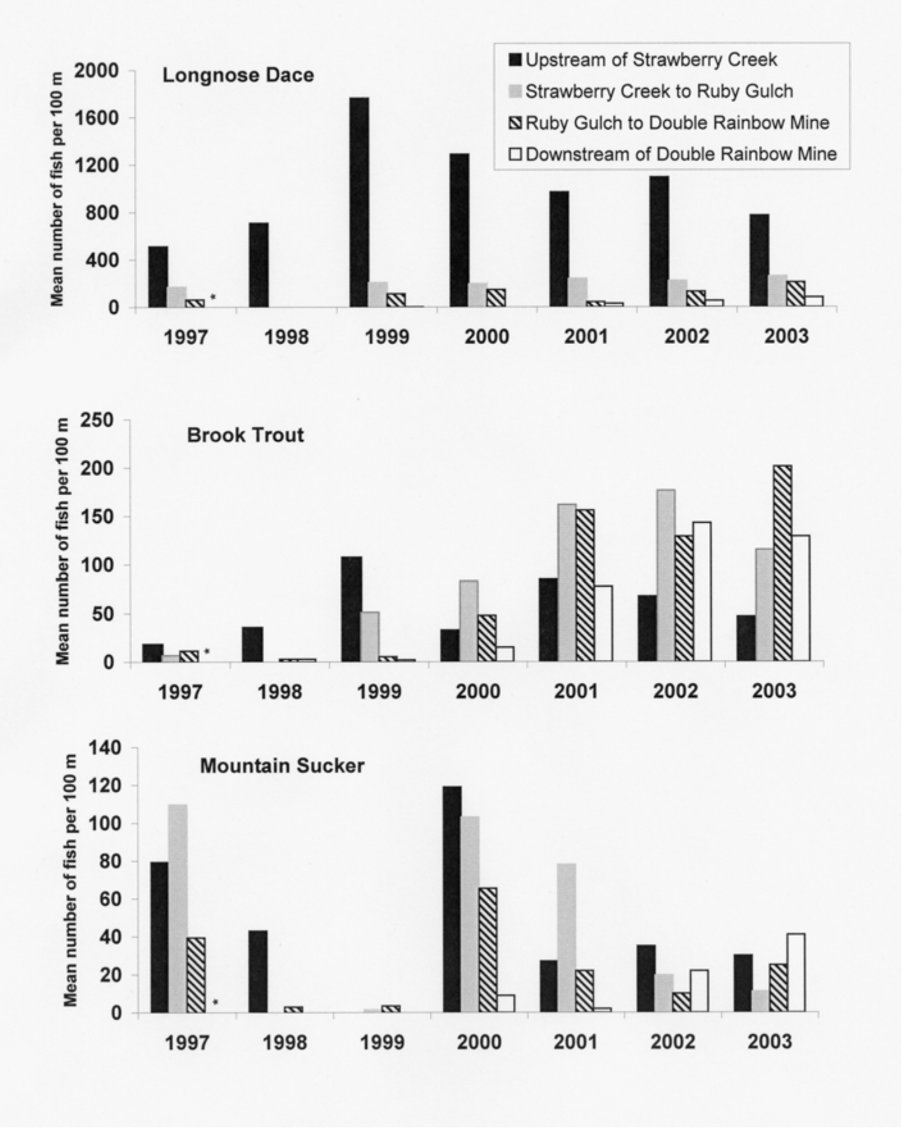

Figure 3. Fish population density estimates in Bear Butte Creek near the Gilt Edge Mine from 1997 to 2003. Asterisk denotes electrofishing surveys were not conducted downstream of the Double Rainbow Mine in 1997.

Discussion

The mountain sucker and the longnose dace are two of only a handful of fish species that are widely accepted as being native to the streams of the Black Hills. Although neither of these species supplies sportfishing opportunities for anglers, SDGFP is responsible for insuring neither are extirpated from South Dakota. Current South Dakota Codified Law (SDCL 34A-8-6) states "The Department of Game, Fish and Parks and the Department of Agriculture shall perform those acts necessary for the conservation, management, protection, restoration, and propagation of endangered, threatened and nongame species of wildlife". Although neither of these species is listed by the State of South Dakota as threatened or endangered, extinctions or declines in native fishes are not unheard of in North America. Miller et al. (1989) reported the loss of 3 genera, 27 species and 13 subspecies of fish from North America in the proceeding 100 years. Patton et al. (1998) documented a decline in 12 of 31 native species of fish in the Missouri River drainage of Wyoming from the 1960s to the 1990s.

Brown trout are more piscivorous than brook trout or rainbow trout. The lack of brown trout within the Bear Butte Creek watershed may explain the high density mountain sucker and longnose dace in this drainage. SDGFP does not stock brown trout in Bear Butte Creek or any of its tributaries within the Black Hills Trout Management Area. However, an unauthorized stocking of brown trout in this drainage could negatively impact the brook trout, longnose dace and mountain sucker populations.

The Bear Butte Creek watershed has been identified by SDGFP fisheries staff as the watershed with the largest populations of longnose dace and mountain suckers within the Black Hills Trout Management Area. The SDGFP fisheries staff is currently working with the EPA to develop post-closure objectives for the Gilt Edge Mine Superfund Site that address non-native as well as native fish issues.

Acknowledgements

We wish to thank Michael Erickson (SDDENR) and Greg Simpson (SDGFP) for assisting with the preparation of the site location map and species distribution figures. Michael Cepak (SDDENR) provided access to documents and records about the history of Mining in the Bear Butte Creek watershed. The SDGFP Region I fisheries staff along with Dan Wall (USFWS) and Dale Hoff (USEPA) assisted with the annual electrofishing surveys in Bear Butte Creek.

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A Collaborative, Multi-Faceted Approach to Yellowstone Cutthroat Trout Conservation in the South Fork of the Snake River, Idaho

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ABSTRACT—The South Fork of the Snake River supports a world-renowned fishery and one of the most important Yellowstone cutthroat trout populations in their historical range. Rainbow trout were a negligible component of the trout population until the late-1980's. In the past 15 years angler and electrofishing surveys have shown a steady increase in rainbow trout to where they are now as abundant cutthroat trout in the upper reaches of the river. In cooperation with other agencies and non-governmental organizations, the Idaho Department of Fish and Game is working on three fronts to protect and maintain the health of the cutthroat population. First, weirs and fish collection traps have been constructed on the four main tributaries to allow collection of cutthroat and rainbow trout spawners. Based on phenotypic examination, cutthroat trout are passed upstream, whereas rainbow and hybrid trout are transported to catch-out ponds. Second, IDFG has been working with Idaho State University and the Bureau of Reclamation to identify and implement flow regimes that are beneficial to cutthroat trout and detrimental to rainbow trout. A comprehensive analysis suggests the magnitude and shape of the spring runoff flows may have a significant effect on the ratio of rainbow to cutthroat trout recruits. Finally, we used an aggressive program combining regulation changes and public outreach in 2003 to encourage harvest of rainbow trout. Prior to 2003, anglers released the majority of rainbow trout caught on the South Fork. In 1996 an estimated 900 rainbow and hybrid trout were harvested out of 12,700 landed, for a retention rate of about seven percent. In 2003, an estimated 5,070 rainbow and hybrid trout were harvested out of an estimated 21,00 landed, for a retention rate of about 25%. Though the 2003 harvest probably equates to around only 10-20% exploitation (depending on size classes included in the estimate), it represents a significant step in an effort to get anglers to take an active role in managing the South Fork cutthroat trout population. Through continued education combined with regulations liberalizing harvest we hope to increase rainbow trout exploitation to 50-70%. We hope the approach used on the South Fork can serve as a model to engage anglers, manage hydrologic regimes, and conserve genetic integrity of native sport fish in other systems.

Introduction

The South Fork of the Snake River, or "South Fork" as the approximately 60 mile reach from Palisades Dam downstream to the confluence with the Henry's Fork is referred to, supports a tremendously popular fishery and one of the most productive and important populations of Yellowstone cutthroat trout in their historical range. This native trout population is one of the few remaining healthy fluvial populations in the Upper Snake basin and therefore has particular biological, ecological, and social value.

The South Fork fishery draws a tremendous number of anglers to eastern Idaho, providing a significant infusion of money to the eastern Idaho economy. A recent economic impact study indicates that anglers spent nearly $14.7 million in 2003 on the South Fork (this figure is actual expenditures and doesn't include any sort of economic multiplier). Such expenditures contribute to a significant outfitting industry, as well as two major drift boat companies headquartered in nearby Idaho Falls.

Much of the appeal of this highly acclaimed fishery lies in the abundance of Yellowstone cutthroat trout. The South Fork is known largely for high catch rates with dry flies, and outfitters advertise that 50 fish/boat in a single day is not uncommon. It is also generally accepted that the high catch rates are a function of cutthroat trout, which tend to be more vulnerable to dry fly fishing than many other trout species.

Several factors threaten the long-term survival of Yellowstone cutthroat trout on a range-wide basis. These include habitat degradation, dewatering, drought, and non-native species. In the South Fork hybridization with non-native rainbow trout and the associated loss of genetic purity is generally recognized as the most imminent threat to cutthroat trout. Rainbow trout, which are not native to the Snake River basin above Shoshone Falls, were stocked throughout the upper Snake drainage for decades before the implications of genetic introgression were recognized. Although rainbow trout stocking in the main-stem and tributaries was discontinued in 1981, a self-sustaining population was established and is, in fact, expanding. In annual electrofishing surveys of the Conant Reach, rainbow trout have increased in abundance from about 1% of the total catch in 1982 to 33% of the catch in 2003 (Figure 1).

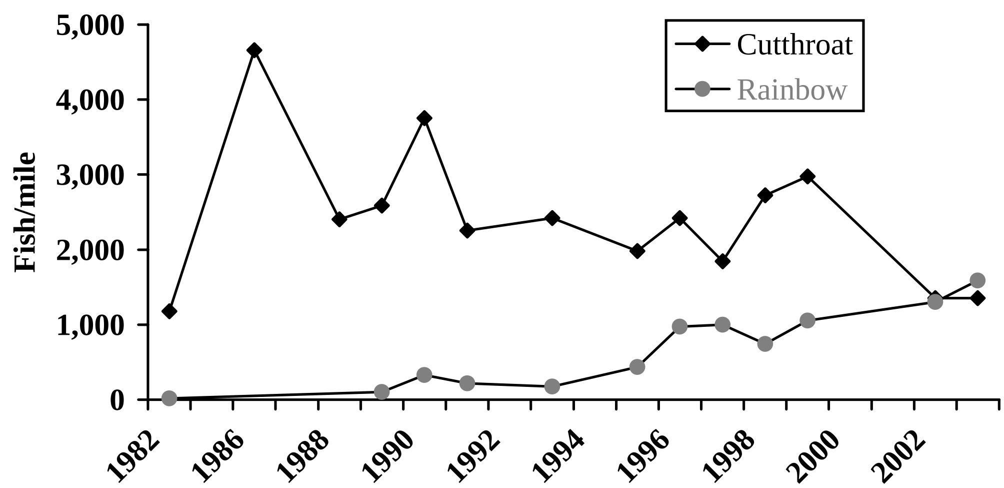

Figure 1. Densities of Yellowstone cutthroat trout and rainbow trout from 1982 through 2003 based on mark-recapture population estimates at near Conant Valley on the South Fork Snake River, Idaho.

Three-prong Approach

The observed rainbow trout expansion in the mid-1990's lead IDFG to begin evaluating available alternatives to insure the long-term survival of Yellowstone cutthroat trout and the associated fishery. A three-prong approach has evolved in the interim period that addresses the need to control the rainbow trout population in the mainstem South Fork and prevent their invasion into tributaries. This approach, which has been developed and implemented largely through a collaborative process, consists of 1) controlling rainbow trout invasion into the major tributaries through the use of fish weirs and traps, 2) implementing flow regimes beneficial to Yellowstone cutthroat trout, and 3) involving anglers in the conservation effort by allowing and encouraging the harvest of rainbow and hybrid trout.

Weirs

A research project was conducted in 1996-1997 to describe where and when rainbow, hybrid, and cutthroat trout spawn. Using radio telemetry, researchers learned rainbow and hybrid trout primarily use main-stem side channel habitat for spawning while cutthroat trout use both main-stem side channel and tributary habitat (Henderson 1999; Henderson et al. 2000).

The research underscored the importance of tributaries in maintaining a genetically pure cutthroat population in the South Fork. As a result, an intensive tributary management program was implemented to preserve the genetic integrity of cutthroat trout spawning in Burns, Pine, Rainey and Palisades creeks. From 1998-2001, in cooperation with the U.S.D.A. Forest Service, the BOR, the Jackson One-Fly Foundation, National Fish and Wildlife Foundation, and Trout Unlimited, IDFG constructed permanent tributary weir and trapping facilities on the four major tributaries with the intent of trapping all upstream migrating trout. Because genetic research has demonstrated near 100% accuracy in field identification of cutthroat with less than 0.5% rainbow trout introgression, IDFG personnel are able to use phenotype to efficiently and accurately sort fish at the traps. Rainbow and hybrid trout are moved to other regional waters where they pose no risk to native species, and cutthroat are allowed to pass upstream to spawn. Because of the extent of mainstem spawning rainbow trout, the intent of the weir program is not to decrease rainbow trout abundance in the mainstem, but rather to prevent invasion of rainbow trout into the tributaries and protect these valuable core areas as genetic refuges for Yellowstone cutthroat trout.

We began the trapping program in March, 2001. Since then, we have successfully trapped and removed over 750 rainbow and hybrid trout spawners and passed over 11,000 Yellowstone cutthroat spawners. Initially, a resistance board floating weir design was used, which is designed to pass debris, thereby minimizing maintenance and increasing effectiveness (Figure 2). Though this design has generally worked during periods of lower flows, it has not consistently been able to withstand the high and variable flows associated with runoff. IDFG is currently working with our agency and non-governmental partners to develop a more effective and efficient weir design. We are optimistic that through modifications of the floating weir design or development of alternative weir structures, we will soon be able to efficiently and effectively trap the vast majority of upstream migrants.

Figure 2. Floating resistance board weir in Pine Creek, Idaho used to divert upstream migrating trout into a collections box (edge of picture in foreground) for phenotypic sorting.

Flows

Palisades Dam was completed by the Bureau of Reclamation (BOR) in 1956, primarily for the purposes of flood control and irrigation water storage. The major impact of the dam, aside from inundation of 19 miles of fluvial habitat and complete blockage of fish migration, was alteration of the hydrograph. Typical of many western river irrigation projects, Palisades Reservoir is operated to store water throughout the winter and spring for delivery in the summer and early fall. The resulting hydrograph is generally one with a minimized peak during the natural runoff period, much higher late summer and early fall flows, and lower winter flows (Figure 3).

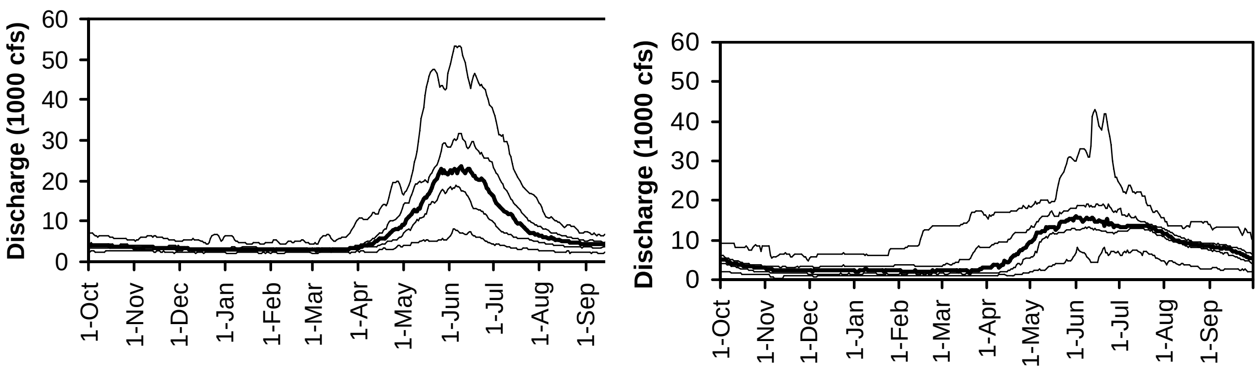

Figure 3. Discharge of the South Fork Snake River, Idaho at the Heise gauging station prior to Palisades Dam (unregulated flow; left), characterized by a pronounced increase in flows in late spring, followed by a return to low flows by late summer, and after the construction of Palisades Dam, charcterized by a moderated and prolonged period of high discharge (right). Bold center line depicts median flow, with the additional lines depicting minimum, 25th percentile, 75th percentile and maximum discharge.

For many years, the focus of fishery conservation efforts was on winter flows. Low winter flows, particularly during dry years, caused significant de-watering of secondary channels of the South Fork, which was believed to cause major losses of juvenile salmonids during winter. The quality and quantity of available winter habitat has been identified as a major factor limiting salmonids abundance in some streams (Mason 1976; Hall and Knight 1981; Tschaplinski and Hartman 1983; Mitro 1999). The expectation was that low winter flows were likely limiting recruitment in the South Fork as well. A multi-agency study of flow-habitat relationships was completed in 1991 that recommended a minimum winter flow release of 1,500 cfs at Palisades Dam (Schrader and Griswold 1994). This target minimum flow was met in the winter of 1995-96 and 1999-2000, but beginning in the winter of 2000-01 flows have not exceed 1,080 cfs because of poor snow pack and low precipitation.

Despite the flow-habitat relationships developed by Schrader and Griswold (1994) there was no conclusive evidence that low winter flows caused poor cutthroat survival. Recognizing drought related constraints on water managers and the uncertainties surrounding the affects of flow regimes, a cooperative project with Idaho State University (ISU) was conducted in 2003 to better define the relationships between flows and fish populations (Moller and Van Kirk 2003). A suite of independent variables that described flow regimes was used in the analyses, including measures of hydrologic alteration (the difference between natural flow and regulated flow), minimum flows, maximum flows, and the ratio of springtime maximum flows to the previous winter minimum flows. The dependent variables were measures of juvenile trout recruitment—specifically age-1 abundance of cutthroat, rainbow, and brown trout as determined by annual electrofishing population estimates in September-October.

A surprising finding was that winter flows were not related to Yellowstone cutthroat trout recruitment, although they were strongly related to rainbow trout recruitment. Ironically, the years where minimum flow exceeded 1500 cfs yielded the strongest cohorts of rainbow trout. Rainbow trout also benefited from years when springtime flows were moderated by flood control. In about one third of the years, water is released from Palisades Dam beginning in late February, resulting in high, but relatively constant flows in the South Fork through June. The higher late winter flows, combined with storage of runoff in late spring, followed by high flows related to irrigation water delivery through mid-fall results in a highly altered flow regime with characteristics more similar to a spring-fed river than a snow-melt driven system.

Not surprising was the finding that years with a more natural flow regime benefited cutthroat trout. Because an unregulated snowmelt driven system is characterized by extreme flows, the ratio of minimum winter flows to the following springtime maximum (max:min ratio) serves as an index of a more natural hydrograph. This ratio was very strongly and positively related to cutthroat trout recruitment, but negatively related to rainbow trout recruitment. The ratio of juvenile cutthroat to rainbow trout was about 8:1 in years with the highest max min ratios, compared to 1:1 in years with the lowest max min ratios.

Based on these relationships, Moller and Van Kirk (2003) recommended that water managers store additional water throughout the winter (i.e., resulting in lower winter flows) for release in the spring to coincide with natural runoff. Fortunately, this scenario, designed to benefit cutthroat trout, is also beneficial to water users, who prefer to store water in the upriver reservoirs throughout the winter, and are amenable to a spring release as long as the water can be caught in a lower reservoir.

This recommendation was implemented in the spring of 2004. Because of the low snow pack, the regulated flow very closely mimicked what flow would have been in the absence of Palisades Dam. Discharge in the South Fork peaked on May 23 at 18,960 cfs (at the Irwin gage), and the max:min ratio was 20.5:1, greatly exceeding the threshold of 10:1 believed to favor Yellowstone cutthroat trout.

Although the mechanism behind the relative success of cutthroat and rainbow recruitment is largely speculative, disruption of gravel and shifting bedload may be a significant factor. Because rainbow trout tend to spawn prior to peak flows, whereas cutthroat trout spawning generally coincides with the descending limb of the hydrograph (Henderson et al. 2000) it seems likely that the redd disturbance may hinder rainbow trout egg survival. Alternatively, a steeply ascending hydrograph may trigger cutthroat trout to initiate a spawning migration or spawn in more favorable habitats. Regardless, we are optimistic that the 2004 flow regime will result in a higher cutthroat to rainbow trout ratio than has been seen in recent years. The effectiveness of the experimental flows will ultimately be gauged by age-1 trout recruitment in the 2005 electrofishing surveys.

Angler Harvest

Like many wild trout fisheries, the South Fork evolved in the 1980's from a largely harvest-oriented fishery to a predominately catch-and-release fishery. A creel survey in 1982 (in the upper river from May through September) indicated that anglers caught almost 48,000 game fish, of which almost 28,000 or 59% were harvested (Moore and Schill 1984). By 1996, the catch had increased to nearly 189,000 fish, but harvest was only 4,568 fish, or 2% (Schrader et al. 2003). The same survey indicated around 900 rainbow and hybrid trout were harvested out of 12,700 landed, for a retention rate of about seven percent. Although regulations had undergone various changes during this period, the harvest was largely limited by self-regulation of anglers. Clearly, with the amount of angling pressure and number of fish handled, anglers have the ability to impact the trout population.

With this in mind, IDFG has worked with Trout Unlimited (TU) and leaders in the local angling and guiding community to develop an aggressive rainbow trout harvest campaign. This has increased the level of awareness and instilled a sense of ownership in the fishery. Initially, we worked with writers and reporters on newspaper articles, editorials, and television news stories. We then developed a brochure describing the cutthroat/rainbow situation that was distributed through sporting goods stores, angling club functions, and fly fishing expos. In addition to the brochures, signs and posters were erected at informational kiosks at the major boat ramps. A key component of the signs were identification criteria to help anglers accurately distinguish rainbow and hybrid trout from Yellowstone cutthroat trout. Most recently, we developed a lapel (or fishing vest) pin awarded to anglers on the river that had harvested a rainbow trout.

As part of the angler education campaign, but also to assess the current fishery, we conducted a creel survey on the South Fork from January through December 2003. In addition to collecting effort, catch, and harvest information, fishery technicians used the creel checks as an opportunity to discuss cutthroat trout management and to stress the importance of rainbow trout harvest.

Fishing rules during the 2003 creel survey allowed anglers to keep six trout (rainbow and hybrid trout could be any size), only two of which could be cutthroat or brown trout (with a 16 inch minimum size). Because IDFG fishing rules are set on a two-year cycle and were up for changes in 2004, we collected public input throughout the creel survey and in a series of public meetings to discuss potential regulation changes to benefit cutthroat trout.

Results of the 2003 creel survey reflected the population trends apparent in the electrofishing surveys. The percentage of cutthroat trout in the catch declined from 71% in 1996 to 48% in 2003, while rainbow trout increased from 7% of the catch to 20% (in the upper river from May through September; Figure 4). Many cutthroat trout advocates have suggested that catch rates may decline as rainbow trout become more dominant, simply because of the greater vulnerability of cutthroat trout. Evidently supporting this hypothesis, catch rates dropped from 1.12 fish/hr in 1996 to 0.64 fish/hr in 2003. We were encouraged that anglers released nearly all cutthroat trout, with less than 300 cutthroat trout kept out of around 55,500 landed. We were also encouraged that many anglers showed a willingness to harvest rainbow trout. We estimated 5,070 rainbow and hybrid trout were harvested. Though the retention rate was much improved over 1996, participation was far from complete, with around 21,000 rainbow and hybrid trout being released (retention rate of around 25%).

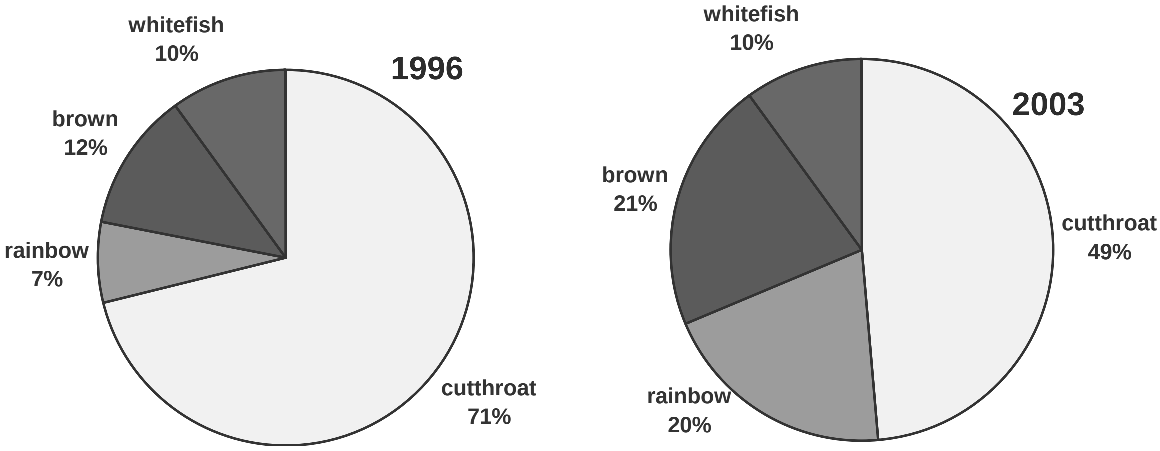

Figure 4. Catch composition based on angler creel surveys conducted in 1996 and 2003 in the upper South Fork Snake River, Idaho from May through September.

We conducted an approximate river-wide population estimate for rainbow and hybrid trout using catch per unit effort (CPUE) at systematically selected sites throughout the river (Schrader and Fredericks, in press). Based on this method, we estimated there were approximately 39,000 rainbow and hybrid trout in excess of eight inches in 2003. This suggests annual exploitation by anglers in that same year was around 12%. Release rates tended to be much higher on smaller fish (8-12 in), however, and when considering only the population of larger rainbow trout (i.e., those over 11 in), exploitation is likely closer to 20%. In either case, we are optimistic that as angler acceptance of rainbow trout harvest mounts along with a native trout conservation ethic we will achieve annual exploitation rates exceeding 50%.

Individual contacts and public meeting comments clearly indicated that most anglers recognized the value of cutthroat trout in the South Fork and strongly supported management actions and rule changes to maintain the cutthroat trout population, even if they had difficulty personally harvesting rainbow trout. In response to the need to encourage rainbow and hybrid trout harvest and protect cutthroat trout, the IDFG commission approved regulations for 2004-05 that allow anglers to keep an unlimited number of rainbow and hybrid trout of any size. In addition, the entire South Fork was opened to year-round fishing, enabling anglers to target spawning rainbow trout in the upper river, where they had previously (and inadvertently) been protected by a general season. Finally, a catch-and-release rule for cutthroat trout was implemented in the mainstem and the major tributaries, and to maximize protection of spawners, a July 1st opening date was applied to the major tributaries.

Although we conducted only occasional and unstructured creel checks in 2004, it seems very evident that the year-round season in combination with allowing unlimited harvest of rainbow and hybrid trout is significantly increasing exploitation. We are optimistic that by 2005, annual exploitation of rainbow and hybrid trout will exceed 40%.

Conclusion

The South Fork represents a unique example of a native fish conservation effort involving water users, anglers, non-governmental organizations, and state and federal agencies. The multi-faceted strategy has been possible because of the extraordinary level of communication amongst stakeholders, a widely held appreciation of the value of the resource, and the recognition of the potential costs of a less productive adversarial atmosphere. We are optimistic the South Fork efforts will ensure a healthy Yellowstone cutthroat trout population into the future. Furthermore, we hope the approach can be used as a model to engage anglers, manage hydrologic regimes, and conserve genetic integrity of native sport fish.

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Managing a Trout Tailwater in the Presence of a Warmwater Endangered Species

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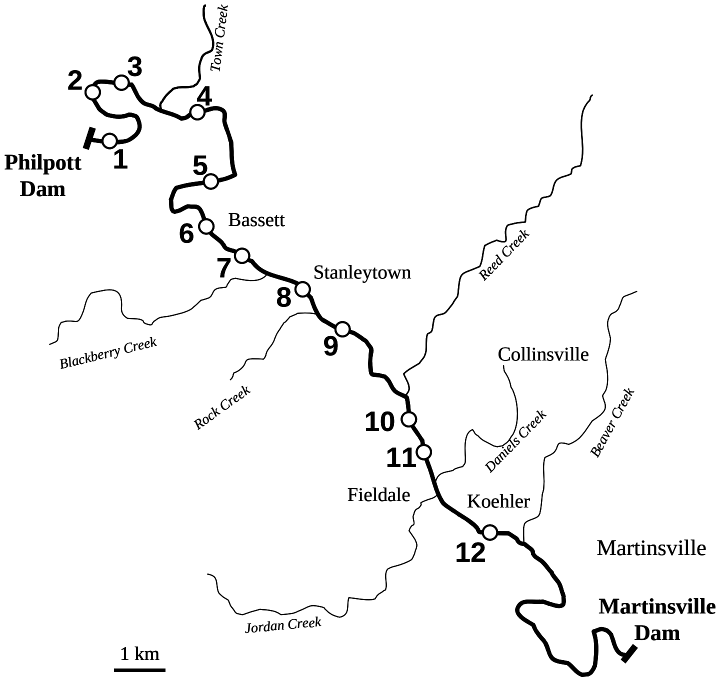
ABSTRACT—Flow and temperature in the Smith River tailwater (southwest Virginia) are influenced by a hydropeaking operation. Hypolimnetic releases support a naturalized brown trout (*Salmo trutta*) fishery and spatially restrict the endemic warmwater ichthyofauna. With trophy trout currently lacking, managers and anglers desire flow and temperature changes to enhance brown trout size and growth. However, management must also protect the endemic warmwater species, including the endangered Roanoke logperch (*Percina rex*). Dynamic flow and water temperature models were used to predict thermal habitat under alternative flow scenarios. Model output and species thermal criteria enabled assessment of potential benefit or detriment to brown trout and warmwater species. Currently the average release temperature (8°C) is below the optimal brown trout growth range (12-19°C). A 12°C outflow scenario predicted the greatest increase of optimal growth temperatures. Warmer temperatures also increase the area of suitable thermal habitat for warmwater species, including the Roanoke logperch. With changes in flow management we found it is possible to improve the trout fishery without detrimental effects to the warmwater community.

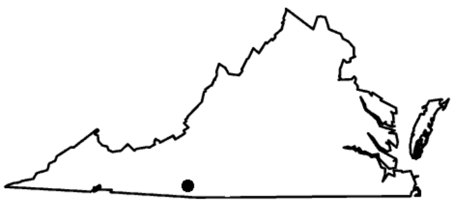
Introduction

Hydroelectric impoundments significantly alter the physical and biotic characteristics of the lotic system they control (Cushman 1985; Bain et al. 1988; Allan 1995). The physical effects of hydropeaking often include altered flow and temperature regimes, scouring, and channel and bank erosion (Bain et al. 1988; Allan 1995). Regulation subsequently affects the biota of the aquatic system both physiologically, and in terms of patterns in species assemblage (Bain et al. 1988; Kinsolving and Bain 1993; Allan 1995; Hunter 2003). However, the tailwaters below hydropeaking facilities have proven to provide economically valuable coldwater sport fisheries in geographic locations that could not otherwise support such species (Krause et al. in press).

The thermal characteristics of aquatic ecosystems hold great importance as to the distribution and vitality of ichthyofauna. Temperature is considered a controlling factor in the metabolism of fish, directly affecting physiological rates and efficiencies (Fry 1971; Ojanguren et al. 2001). Hinz et al. (1998) indicate that the thermal regime significantly contributes to growth variations spatially within a system. The process of seeking optimal temperatures in order to regulate metabolic expenditures is an important aspect of life-history in many fish (Hall 1972). Longitudinal differences in stream fish distribution are often a result of the independent responses of species to physiochemical gradients, rather than biotic interactions (Moyle and Li 1979; Matthews and Styron 1981). For this reason, temperature has been viewed as both a resource and a habitat among stream fishes (Magnuson et al. 1979; Ojanguren et al. 2000; Wehrly et al. 2003).

The Smith River is a sixth order tributary of the Dan River located in southwestern Virginia (Figure 1). In 1952, the U.S. Army Corps of Engineers impounded a section of the Smith River with the construction Philpott Dam, resulting in the creation Lake Philpott and the tailwater section of the Smith River. Philpott Dam generates peaking releases year-round, with generation schedules determined by energy demands and water availability. Due to peaking releases, flows fluctuate daily, excluding weekends, between 1.3 cms to 36.6 cms. The temperatures of peaking releases average 8°C, and increase with distance from the dam (Krause 2002). Due to peak flows, temperatures fluctuate hourly, declining up to 10°C in an hour during summer months (Krause 2002). The Smith River tailwater is home to an economically valuable, naturalized population of brown trout (*Salmo trutta*), stocked rainbow trout (*Oncorhynchus mykiss*), as well 33 nongame fish species, including the endangered Roanoke logperch (*Percina rex*). The tailwater, once a trophy brown trout fishery, now produces few trout that exceed 406mm (0.63kg) (Hartwig 1998; Orth et al. 2001; 2002; 2003; Hunter 2003).





Site #	Km below Dam	Section
1	0.5	
2	3.4	Upper
3	4.2	
4	6.2	Trophy
5	8.9	
6	11.9	
7	13.1	
8	14.9	
9	16.5	Lower
10	19.5	
11	20.6	
12	23.7	

Figure 1. Fish sampling sites, which also correspond to temperature model output locations, are numbered upstream to downstream in the Smith River tailwater, southwestern Virginia.

The Roanoke logperch, a large darter, is a noteworthy constituent of the Smith River's nongame fish assemblage due to its rarity. Characteristic of other species in the genus *Percina* , the Roanoke logperch is known to feed primarily on benthic and drifting invertebrates (Jenkins and Burkhead 1993). Rosenberger (2002) concluded that Roanoke logperch are extremely vulnerable to habitat degradation. The Roanoke logperch has a very small total range, and low population densities, occupying several warmwater streams in the Roanoke, Chowan, and Smith River drainages in Virginia (Jenkins and Burkhead 1993). In the Smith River drainage, small populations of Roanoke logperch are found above Philpott Dam, in the lower reaches of the tailwater, as well as in one of the primary tributaries, Town Creek, located approximately 5 km below the dam. Jenkins and Burkhead (1993) state that the Town Creek population is thermally isolated from the population that inhabits the tailwater further from the dam.

We hypothesize that water temperatures in the tailwater, a function of hydropeaking operations, may be limiting trout growth, as well as spatially restricting the distribution of the endangered Roanoke logperch. In this study, we modeled alternative flow scenarios for the Smith River tailwater to determine if there is a temperature regimen that can enhance the growth of brown trout, as well as increase thermal habitat for Roanoke logperch, and similar warmwater species.

Methods

Flow and Temperature Model Development

The influence of alternative flow scenarios released from Philpott dam on water temperature were compared to the baseline flow regime released by the U.S. Army Corps of Engineers (USACE). Hourly flow and temperature was predicted with the dynamic ADYN and RQUAL river modeling system (Hauser and Walters 1995). Flow scenarios were modeled by season (Spring: Mar, Apr, May and Summer: Jun, Jul, Aug) under representative conditions calculated for lateral inflows, lateral inflow temperature, meteorological parameters, and starting water temperature at the upstream modeled end. Spring and summer seasons were chosen for further analysis because of their biological interest in terms of spawning activity and growth patterns. Hourly model output at 12 locations below Philpott dam which correspond to fish sampling sites of a Smith River brown trout study were assessed together as a tailwater, as well as within the upper (0.0-5.3 km), trophy trout managed (5.3-10.0 km), and lower (10.0-24.3 km) reaches (Orth et al. 2003) (Figure 1). Because the representative conditions did not change between the baseline and alternative scenario model runs, comparisons assess changes resulting from an alternative scenario. Alternative scenarios were evaluated for ability to increase occurrence of brown trout optimal growth temperatures (12-19°C), prevent exceedance of 21°C (brown trout maximum), maintain diurnal flux, and reduce maximum hourly temperature declines (MHTD). Detailed methods for model parameter data collection, input file development, calibration, predictive ability, and validation can be found in Krause (2002).

The baseline flow regime was determined using 13 years (1991-2003) of discharge data (USGS 2004). Histograms were used to determine occurrence frequency of typical conditions for baseflow discharge; drawdown discharge prior to peaking flow; and time-of-day of peaking flow. The typical magnitude and duration of peakflows were determined as the average of what occurred. The combination of these variables enabled the development of a representative baseline flow regime released by the USACE each season.

Lateral inflows were calculated for three sections of the tailwater and the Town Creek tributary (Krause 2002). The difference in flow between multiple gages estimated lateral inflows. Seven years of hourly data for cloudiness, dry bulb temperature, dew point, barometric pressure, and wind speed were obtained from the National Climatic Data Center (NCDC 2004) and solar radiation data from the Cooperative Networks for Renewable Resource Measurements (CONFRRM 2004). Representative meteorological parameters were generated as an average across years (1997-2003) within a season (spring and summer) for each of the 24 hours in a day. Water temperature was recorded by data loggers (Krause 2002). The upstream-most logger provided temperatures to initiate the RQUAL model and loggers in tributaries provided lateral inflow temperature data. Mean annual air temperature was also used for lateral inflow temperature depending on season (Krause 2002). Additional temperature loggers were used for model calibration and validation. The average of hourly temperature logger data across years (1999-2003) within a season for each of the 24 hours in a day provided representative conditions.

Three alternative flow scenarios were developed based on two potential modifications to Philpott dam; a depth variable intake allowing selective water temperature release or replacement of the 1950's era turbines with modern turbines. The *12°C outflow scenario* assumes 12°C water within the reservoir is released using the baseline flow regime to achieve temperatures within the reported brown trout optimal growth range (12-19°C) (Table 1) (Raleigh et al. 1986; Smith 1994; Ojanguren 2001). The *new turbines scenario* cuts the baseline peakflow magnitude in half and doubles the duration of the peakflow release. The *steady baseflow scenario* releases a constant non-peaking flow. This scenario releases a discharge 3.7 to 7.3 times greater (depending on season) than is presently released in order to account for the average seasonal inflow into the reservoir. This increase in baseflow is within the recommend range to maximize available habitat for all life stages of brown trout in the Smith River (USFWS 1986).

Table 1. Characteristics of the baseline and alternative flow scenarios. The peakflow, release duration, and release time were not applicable (NA) to the steady baseflow scenario.

Season	Scenario	Peakflow (m^3/s)	Baseflow (m^3/s)	Release Duration (hrs)	Release Time	Outflow Temp. (°C)
Spring	Baseline	31.3	1.4	6	7:00	7
	12°C Outflow	31.3	1.4	6	7:00	12
	New Turbines	15.6	1.4	12	7:00	7
	Steady Baseflow	NA	10.2	NA	NA	7
Summer	Baseline	31.8	1.5	5	14:00	9
	12°C Outflow	31.8	1.5	5	14:00	12
	New Turbines	15.9	1.5	10	14:00	9
	Steady Baseflow	NA	5.5	NA	NA	9

Thermal Preferences of the Roanoke Logperch

We reviewed literature to determine the extent of knowledge concerning thermal preferences of the Roanoke logperch (*Percina rex*), as well as related species (i.e. *Percina caprodes, Percina burtoni*). In addition, we contacted several investigators familiar with the life history of the Roanoke logperch.

Roanoke logperch were collected and identified during one week in June (summer) over a three-year period (2000, 2001, and 2002) and one week in April (spring) over a two-year period (2001, 2002) in the Smith River tailwater. Fish were collected at 12 study sites representing the longitudinal gradient of the tailwater (Figure 1). Sampling was performed via electrofishing a 100m blocked section with a three-pass depletion method. Using the temperature modeling methodology described above, temperatures were modeled for each of the 12 sampling sites in the tailwater for the month of April during the years 2001 and 2002 and during the month of June in the years 2000, 2001, and 2002.

A presence-absence matrix was developed to determine at which study sites Roanoke logperch were present or absent during each sampling event. A monthly average water temperature was computed for each of the twelve sites during the month the sampling occurred. To derive a lower thermal threshold for presence, the lowest average temperature at sites where logperch were present was computed for all years during the two seasons sampled.

Results

Temperature Predictions under Baseline and Alternative Scenarios

The 12°C outflow scenario provided the greatest increase in occurrence of 12-19°C temperatures during spring and summer by 50% and 25% over baseline conditions throughout the tailwater, respectively (Table 2). The improvement in water temperature from the 12°C outflow scenario was greatest in the upper section (0.0-5.3 km) of the tailwater (Figure 2), where occurrence of 12-19°C temperatures increased from 0% to 60% in spring, and 9% to 100% in summer (Table 2). Scenarios involving modern turbines (the new turbine and steady baseflow scenario) caused little to no improvement of optimal growth temperatures (Table 2). None of the scenarios caused water temperature to exceed the Department of Environmental Quality maximum 21°C standard during any season, with the exception of the 12°C outflow scenario, which only caused a 1% exceedance in the lower section (10.0-24.3 km) during summer (Table 2). During summer, the steady baseflow scenario caused the largest decline (up to 3°C) in diurnal flux (Table 2). Minimal to no change occurred for spring. Hourly declines in temperature only exceeded the DEQ 2°C standard in summer and the steady baseflow scenario caused the greatest reduction of MHTD (1-4°C). The 12°C outflow scenario was the only scenario able to elevate the average temperature from baseline conditions during spring and summer (Table 2). The increase in average temperature was greatest in the upper section (Figure 2); 4°C increase in spring and 3°C in summer.

Table 2. Temperature predictions for baseline conditions and alternative scenarios shown as percent time temperature was within 12-19°C, percent time 19°C & 21°C was exceeded, diurnal flux (°C), maximum hourly temperature decline (MHTD °C), and average temperature (°C). Values are averages for a one week period (Tuesday-Monday) from 0.5 to 23.7 rkm below Philpott dam by season. In parenthesis are model predictions averaged within the upper, trophy trout managed, and lower section of the tailwater.

Season	Scenario	%12-19°C	% >19°C & <21°C	%>21°C	Diurnal Flux (°C)	MHTD (°C)	Avg. (°C)
Spring	Baseline	10 (0,7,15)	0 (0,0,0)	0 (0,0,0)	3 (3,4,3)	1 (0,1,2)	10 (8,10,11)
	12°C Outflow	60 (60,47,64)	0 (0,0,0)	0 (0,0,0)	3 (3,4,2)	0 (0,0,0)	12 (12,12,12)
	New Turbines	10 (0,7,15)	0 (0,0,0)	0 (0,0,0)	3 (2,3,2)	1 (0,1,1)	9 (7,9,10)
	Steady Baseflow	0 (0,0,0)	0 (0,0,0)	0 (0,0,0)	3 (2,3,3)	0 (0,0,0)	9 (7,8,9)
Summer	Baseline	55 (9,76,68)	14 (0,0,24)	0 (0,0,0)	6 (3,6,7)	3 (2,3,4)	14 (10,14,16)
	12°C Outflow	80 (100, 96,66)	20 (0,4,33)	0 (0,0,1)	5 (3,5,6)	2 (1,3,3)	16 (13,15,17)
	New Turbines	50 (10,63,64)	14 (0,0,25)	0 (0,0,0)	6 (3,7,7)	2 (1,3,2)	14 (10,13,16)
	Steady Baseflow	64 (4,40,97)	0 (0,0,0)	0 (0,0,0)	3 (2,4,3)	0 (1,1,0)	13 (10,12,15)

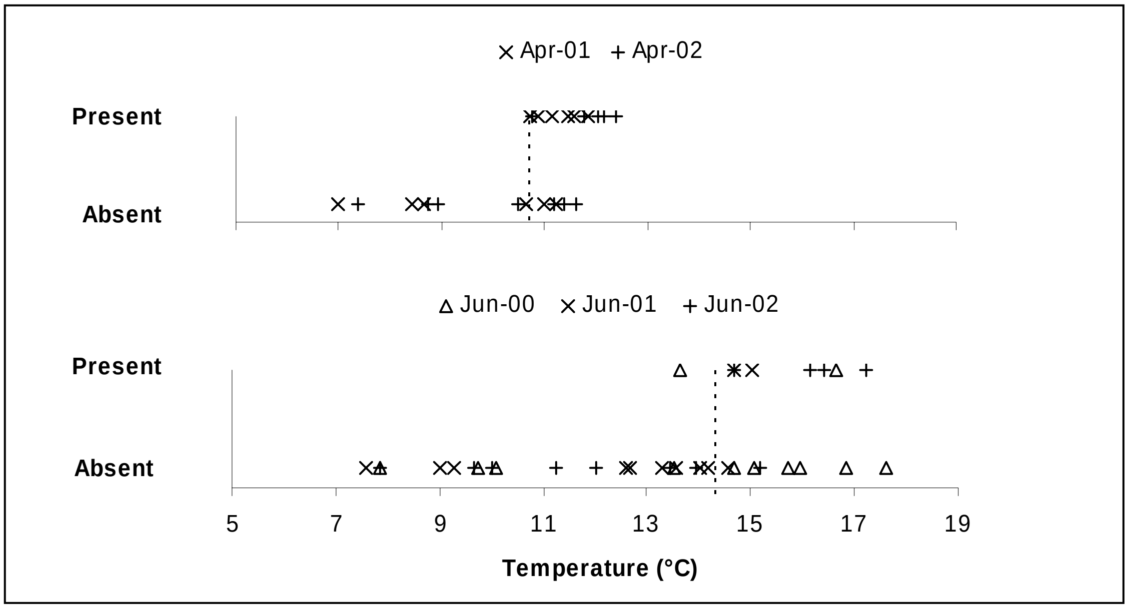


Figure 2. Presence-absence of Roanoke logperch along a temperature gradient for April (spring) and June (summer). The dashed line indicates the lower threshold temperature presence value. No sites were sampled at higher temperatures.

Thermal Habitat for Smith River Fish Species under Alternative Scenarios

Given Roanoke logperch presence-absence information, as well as average temperatures, a threshold temperature value for presence was determined for spring (10.73°C) and summer (14.34°C) seasons (Figure 2). During spring, the12°C outflow scenario provided substantial improvement, increasing the logperch's potential range to include the entire tailwater (Figure 3). During summer, the 12°C outflow scenario predicts the greatest potential increase of logperch presence throughout the tailwater, by increasing water temperatures above the threshold value at 5 km rather than 10 km (Figure 3).

Assuming that the growth of brown trout in the Smith River tailwater would improve under an increased occurrence of optimal growth temperatures (12-19°C), only the 12°C outflow scenario provided improvement in all reaches during spring, and the dam reach in summer (Figure 3).

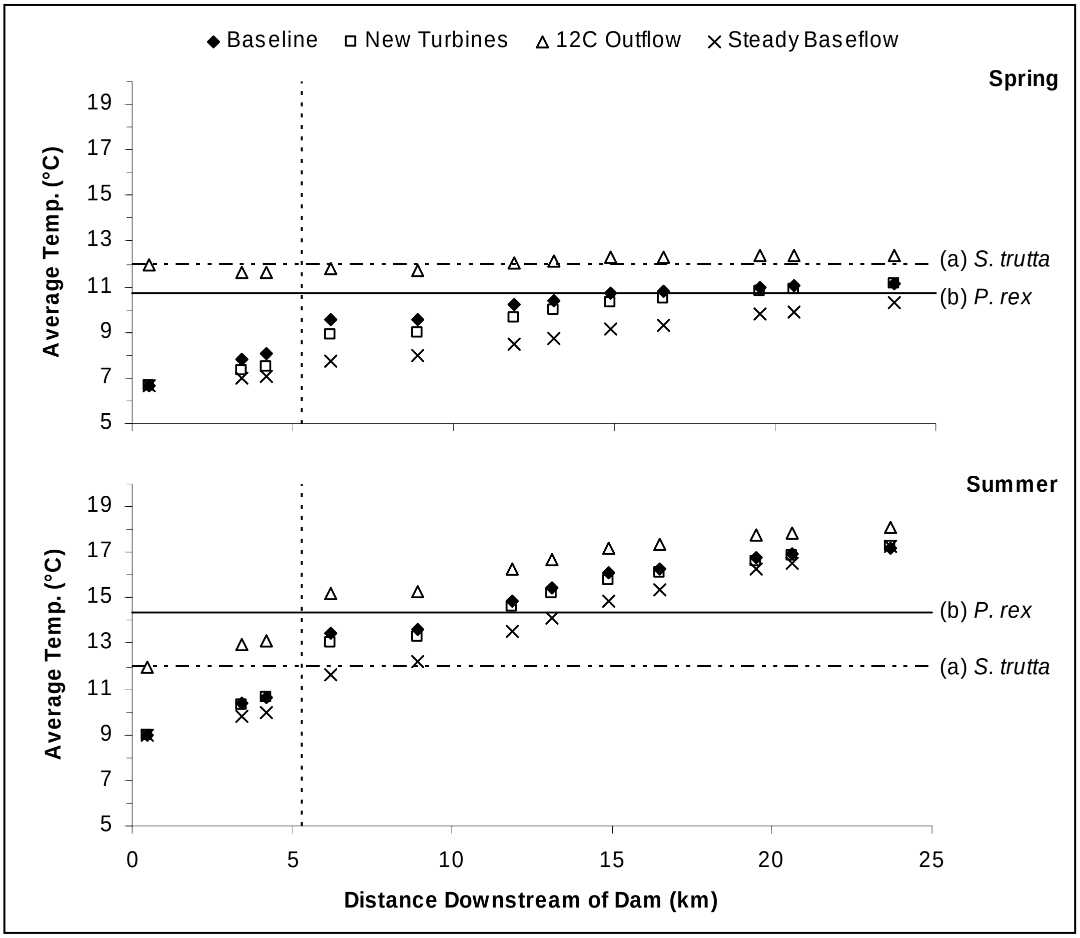


Figure 3. Spring and summer average temperature predicted under alternative flow scenarios in relation to distance downstream of Philpott Dam. Horizontal lines represent (a) the lowest optimal growth temperature for brown trout (*S. trutta*) and (b) the threshold temperature presence value for Roanoke logperch (*P. rex*). The vertical dashed line indicates the location of Town Creek.

Discussion

These results show that the effective management of trout and endemic warmwater species in hydropeaking tailwaters are not necessarily mutually exclusive. In addition, our study emphasizes the importance of deliberate, informed flow management to alter the ichthyofauna of tailwaters.

The Smith River is a tailwater fishery that holds possibilities for improvement. Many authors have emphasized the importance of water temperature upon growth and survival of fish (Fry 1971; Hinz 1998; Ojanguren 2001). Our study suggests that slightly altering the temperature of peaking releases may provide a greater physiological potential for growth among the naturalized brown trout. Additionally, this flow scenario requires no change in peaking operations, allowing the controlling agency to continue meeting hydroelectric energy demands (Krause et al. in press).

Water temperature also strongly influences the patterns of distribution of stream fishes (Matthews and Styron 1981; Matthews 1987; Hawkins et al. 1997). In addition to improving the conditions for trout growth, our predicted alternative flow scenario may also increase the habitable area of the tailwater for the endangered Roanoke logperch. Logperch have been observed to spawn during mid-April to early May in waters between 12 and 14°C (Burkhead 1983; Jenkins and Burkhead 1993). Our results show that during April, a 12°C outflow scenario would permit suitable spawning temperatures to pervade the entire tailwater, thereby significantly increasing the chance of spawning success. This scenario may provide an additional benefit to the conservation of Roanoke logperch in the Smith River tailwater. Jenkins and Burkhead (1993) indicate that two populations of Roanoke logperch exist within the vicinity of the tailwater. One population occupies downstream reaches of the mainstem; the other inhabits Town Creek, thermally isolated from the mainstem population. Our 12°C outflow scenario predicts that temperatures would become suitable for Roanoke logperch upstream of Town Creek, allowing for the spatial connection of two previously isolated habitats.

Roanoke logperch are often classified as a warmwater stream fish (Burkhead 1983; Jenkins and Burkhead 1993; A. Rosenberger, University of Idaho, pers communication). Conditions that increase the potential range of the logperch may also increase the range of other warmwater nongame fish in the tailwater. Releasing the spatial restrictions of nongame fish imposed by the current temperature regimen may provide an indirect benefit to brown trout in the tailwater by increasing the forage available to them.

We assume that increased water temperatures result in increased trout growth. Continuing studies on the Smith River tailwater using bioenergetics modeling and *in situ* sampling will determine whether increased temperatures do in fact enhance trout growth. Additionally, we concede that the life history and true temperature preferences of the Roanoke logperch are not yet well known (especially summer optimum). Due to small populations and low densities, our data on logperch are limited. Finally, realistic changes in flow management to enhance both the economic and ecological integrity of the tailwater require a significant initial investment of time and resources, and the cooperation of agencies.

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Research and Management of Rainbow/Steelhead Populations in the Kalama River, Washington: A Smorgasbord of Life History Forms, Regulations, and Fishing Opportunities

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ABSTRACT—Evolutionary forces and human intervention have produced a variety of stocks and life history forms of rainbow trout (*Oncorhynchus mykiss*) in the Kalama River, Washington. There are indigenous populations of anadromous steelhead in both summer and winter run forms, as well as a resident (non-anadromous) population with unknown ecological and phylogenetic relationships to the anadromous forms. Added to that mix to bolster recreational fisheries throughout the last half century are summer and winter run forms of artificially propagated steelhead of non-local stock origins. Finally, artificially propagated summer and winter steelhead spawned from the local wild stocks have been introduced for the past several years to evaluate the efficacy and risks associated with that alternative form of hatchery production. Ongoing research of Kalama steelhead have provided some insights regarding the often competing goals of wild stock conservation and hatchery stock utilization. Evidence confirms some suspected risks, but also suggests some measure of success in achieving those goals in the Kalama. Successful conservation of the anadromous and resident wild populations, while providing diverse recreational fisheries was aided by a number of factors, including: natural habitat features, management actions, biological attributes of the fish, and good fortune.

Introduction

Concurrent management of sympatric resident and anadromous forms of *Oncorhynchus mykiss* (rainbow trout and steelhead) poses challenges. For example, management objectives and fishing regulations for the two forms may conflict, such as when incidental catch in trout fisheries impacts the survival of juvenile steelhead. Incomplete understanding of the biology and population structure of the two life history forms increases the challenge (Kostow 2004). Another layer of complexity is added in the case of the Kalama River in southwest Washington, which has sympatric indigenous populations of both summer and winter run forms of steelhead. The complexity increased another notch when non-local origin hatchery stocks of both summer and winter run forms were introduced in the 1950s to provide more sport harvest. Recently, two additional hatchery stocks of "wild broodstock" steelhead have been added. The two new stocks were spawned from adults of the indigenous wild summer and winter populations, to achieve both research and sport harvest objectives (Sharpe et al. 2000; Hulett et al. In press). Research conducted on Kalama steelhead since 1975 has provided considerable information on the biology and population interactions among the indigenous wild stocks and the transplanted hatchery stocks. That information helped guide decisions on Kalama steelhead management, which aims to provide harvest of hatchery fish while also achieving wild stock conservation objectives. Despite the complicated mix of stocks and life history types involved, the Kalama continues to support one of the few relatively healthy wild summer-run populations in western Washington, as well as a robust wild winter-run population. In this paper, we describe the elements of past management decisions, research information and objectives, river basin traits, fish population attributes, and even some luck, that all played a role in the development and success of steelhead management strategies used in the Kalama.

Background

The Kalama River drains an area of 531 km^2, flowing westerly from headwaters on the southwest flanks of Mount St. Helens to its confluence with the lower Columbia River at river km 117 (Figure 1). Populations of both summer-run and winter-run steelhead as well as non-anadromous rainbow trout are endemic to the Kalama, as are *Oncorhynchus clarki* (cutthroat trout), *Oncorhynchus tshawytscha* (chinook salmon), and *Oncorhynchus kisutch* (coho salmon). Returning adults from the summer-run steelhead population enter the river from April through December (July peak) and over-winter in the upper Kalama basin prior to spawning in the late winter and spring. In contrast, the winter-run population enters the river from November to early June (April peak) just prior to spawning in late winter and spring. Beginning in the late 1950s, hatchery summer and winter steelhead of non-local stock origin were transplanted annually to the Kalama from two hatcheries located on other lower Columbia River tributaries. The hatchery summer-run fish were from Skamania Hatchery on the Washougal River and had broodstock origins from of native Washougal and Klickitat Rivers. The hatchery winter-run fish were from Beaver Creek Hatchery on the Elochoman River and had broodstock origins from multiple sources (Crawford 1979) including the Elochoman River, Chambers Creek Hatchery (southern Puget Sound) and Cowlitz Hatchery (Figure 1). Traditionally, there were no hatchery steelhead reared in the Kalama basin, as Kalama facilities were focused on salmon production. A fishway and trap adjacent to a barrier falls at Kalama Falls Hatchery (river km 17) provides access to upstream migrant salmonids in the Kalama River. Except in recent years (explained later), all steelhead (hatchery or wild) collected in the trap since 1976 have been enumerated and passed upstream. Summer-run steelhead are able to jump the barrier falls during low flow months of May to September, resulting in approximately 50% of the run bypassing the fishway by jumping the falls (Bradford et al 1996).

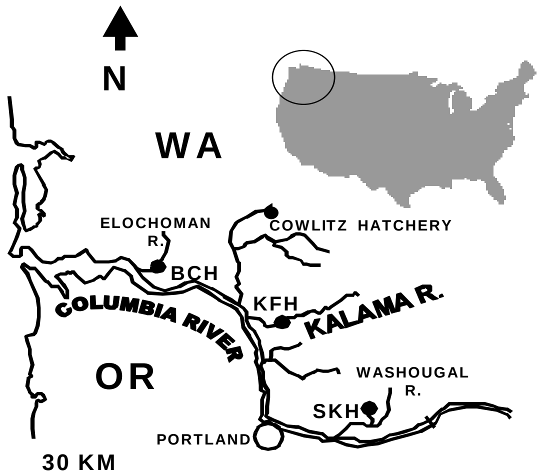

Figure 1. Location of the Kalama River and Kalama Falls Hatchery (KFH) in the lower Columbia River drainage in relation to Beaver Creek Hatchery (BCH) on the Elochoman River, Cowlitz Hatchery on the Cowlitz River, and Skamania Hatchery (SKH) on the Washougal River.

Adaptive Management

Early Years

The combination of the hatchery and wild summer and winter stocks returning to the Kalama provided a popular steelhead fishery, with adult fish present in the river year-round. The hatchery winter-run stock (selected for early return and spawn timing) provided an early winter fishery while the wild winter-run returns peaked in April and continued through May. The hatchery and wild summer-run both provided harvest opportunity from May through the fall. While the hatchery stocks were managed solely to provide harvest, the wild stocks were managed to achieve wild escapement goals and their abundances were tracked separately. This separate management of the hatchery and wild stocks helped both to maximize harvest on the hatchery stocks, and to permit annual abundance estimates of the wild populations. In addition, the early run timing of the hatchery winter-run permitted a focused fishery on that stock and helped minimize inclusion of hatchery fish in spring wild winter-run spawner surveys. All these factors contributed to the ability to separately enumerate and manage the hatchery and wild stocks.

Fishery regulations implemented decades ago, coupled with some features of the Kalama basin, provided extra protection to the wild stocks. Key among these was the creation of a closed waters (no fishing) sanctuary in the upper watershed. Though boundaries were changed somewhat over the years, the current sanctuary extends from river km 34 to river km 59 where Upper Kalama Falls blocks upstream fish passage. This 25 km closed section represents over 40% of the anadromous zone of the Kalama River (Figure 2).

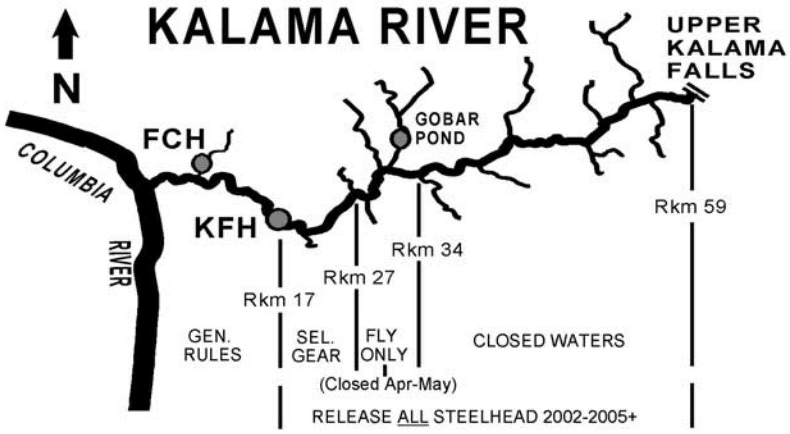

Figure 2. The anadromous portion of the Kalama River basin from the mouth to the impassible Upper Kalama Falls. Fish rearing facilities shown are Fallert Creek Hatchery (FCH), Kalama Falls Hatchery (KFH), and Gobar Pond, an earthen rearing pond on Gobar Creek. Also shown are the four sections with differing fishing regulations as described in the text.

Immediately below the closed waters is a 7 km stretch that was designated as a fly-fishing only section more than 50 years ago (originally including the stretch from river km 17-27 as well). Though that section has long been popular and well known as the “Holy Water” among fly fisherman, it has tended to receive less pressure in recent years than lower sections of the river.

Another factor that increases the benefit of the upper river sanctuary is the water temperature influence of cold springs in the upper basin. The primary headwater source of the Kalama River is Kalama Spring, a cold springs which bubbles up out of the volcanic rock on the lower flanks of Mount St. Helens. There are also numerous smaller cold springs that add to the cold flow input around and above the upper falls area. The collective effect of these cold water sources can result in mainstem Kalama River water temperatures near the upper falls being up to 9 ˚C colder than at Kalama Falls Hatchery (KFH). Furthermore, the mean daily water temperatures at the upper falls only varied from 4 to 9 ˚C over the whole year, as opposed to a range from 1 to 17 ˚C at KFH (Figure 3). Thus, the upper basin has more favorable late summer water temperatures than are found in the lower basin. Also, during extreme cold periods (see early January in Figure 3), the upper basin water temperatures were warmer (4 ˚C) than at Kalama Falls Hatchery (1 ˚C).

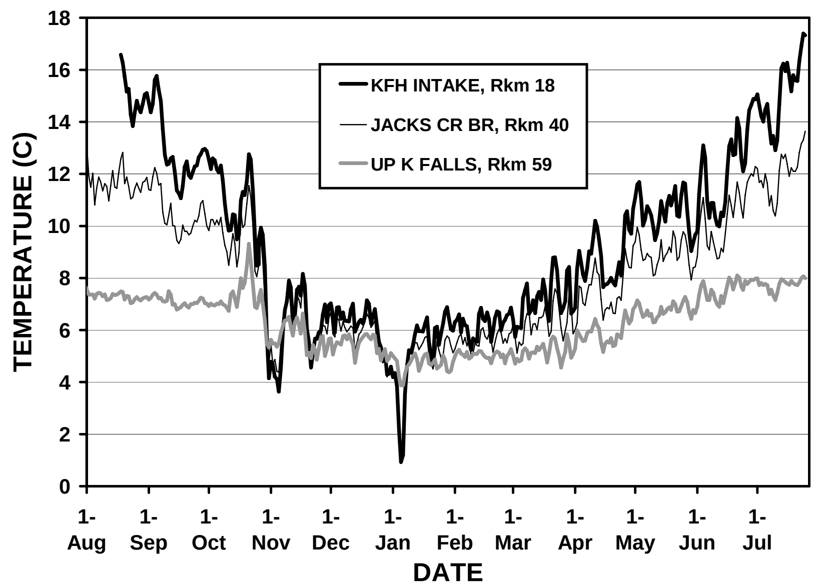

Figure 3. Mean daily water temperatures of the mainstem Kalama River at three sites from Kalama Falls Hatchery to Upper Kalama Falls, from August 2003 through July 2004. As discussed in the text, the upper site is heavily influenced by cold spring water sources, while the lower sites are more influenced by ambient air temperature and surface runoff sources that are generally warmer than the spring water.

Harvest Restrictions

A major change in Kalama steelhead management in more recent decades was the implementation in 1986 of wild steelhead release regulations for Kalama wild summer-run. This was followed by similar release requirements for the winter-run in 1991, as both stocks were failing to regularly meet their established escapement goals of 1000 adults each. Harvest on wild fish, which had ranged from 700-1600 adults for the summer-run (1982-1985) and from about 200-1600 adults for the wild winter-run (1983-1990), was thus reduced to near zero (compliance is not 100%) following the regulation change (Figure 4).

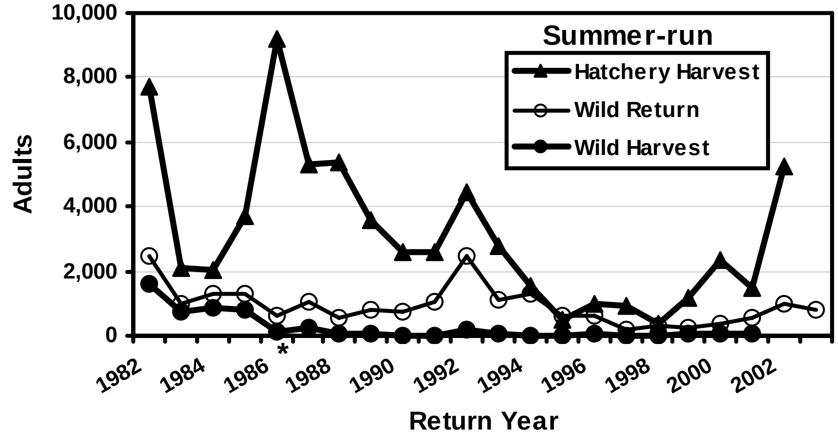

Figure 4. Angler harvest of hatchery and wild summer steelhead, and total returns of wild summer steelhead, in the Kalama River from the 1982 through 2003 summer-run return years. Regulations requiring the release of wild steelhead were implemented in 1986, marked by an asterisk on the return year axis.

Despite this conservation action, wild summer-run returns did not increase notably following implementation of the wild release regulation, apart from one good return year in 1992. Poor ocean survival conditions through the rest of the 1990s led to a steady decline culminating in all-time low returns of 200-300 wild summer-run from 1997 to 1999. That was followed by improved ocean survival conditions and gradual rebuilding to return levels of about 1000 and 800 in 2003 and 2004, respectively (Figure 4). The lack of increase in numbers should not be interpreted as a failure of the wild release regulation. Rather it emphasizes the importance of the regulation: had harvest been allowed during those years of low returns, the spawning escapements would have been reduced even further (wild harvest rates averaged over 65% from 1983 to 1985).

Winter-run returns followed a similar pattern, but with a less precipitous decline ending in lows near 500 fish from 1997 to 1999. However, the winter-run recovered more quickly following the return to favorable ocean conditions, increasing from 500 to over 2100 in five years (Figure 5).

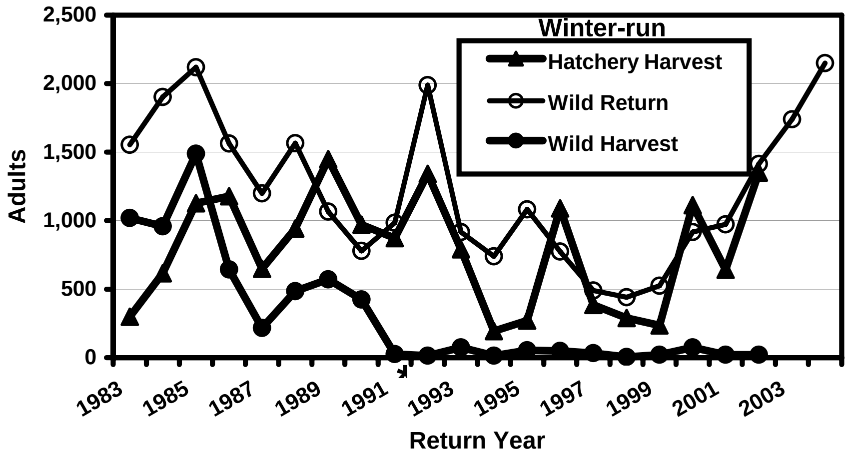

Figure 5. Angler harvest of hatchery and wild winter steelhead, and total returns of wild winter steelhead, in the Kalama River from the 1983 through 2004 winter-run return years. Regulations requiring the release of wild steelhead were implemented in 1991, marked by an asterisk on the return year axis.

Hatchery-Wild Interactions

The next major change in the management of Kalama steelhead involved reducing the risk of negative interactions between the wild stocks and the non-local origin hatchery stocks. The question of whether naturally spawning hatchery fish posed genetic risks to the wild populations was formally posed in a report commissioned by the Washington Department of Game to review its hatchery program (Royal 1972). Research conducted on the Kalama River for the next two decades evaluated the reproductive success of the hatchery stocks relative to the wild Kalama stocks spawning naturally in the Kalama River. Those studies concluded that while the hatchery fish contributed substantial numbers of naturally produced juvenile offspring, their production of returning adult offspring (per adult spawner) was considerably lower than that of wild Kalama adults (Chilcote et al. 1986; Leider et al. 1990; Campton et al. 1991; Hulett et al. 1996). Other work found that hatchery and wild fish would likely interbreed to some degree, as the populations were only partially reproductively isolated by time and place of spawning (Leider et al. 1984).

These findings suggested that naturally spawning hatchery stocks posed ecological and genetic risks to wild fish. To reduce those risks, efforts began in 1997 to exclude returning adults of the non-local hatchery stocks from key wild steelhead spawning and rearing habitat, above Kalama Falls Hatchery. A flexible plastic mesh curtain was hung from cable over the top of the falls (Figure 6) during the summer months to prevent fish from jumping the falls (Sharpe et al. 2000).

All wild adults from the trap were passed upstream, and summer-run were given a pink Floy® tag for visual identification during late summer snorkel surveys. In 1997, 500 hatchery summer-run were passed upstream as a consolation to the upriver fishery. In subsequent years, all hatchery adults were marked (by colored tags or a caudal punch) and trucked to downstream release sites to reenter the lower river fishery. In early September the entire mainstem Kalama above KFH was surveyed by snorkelers to assess the efficacy of the barrier by estimating the number of successful "jumpers" (jumpers would have no tag, or a tag of a color other than pink). The result was a very high reduction in the upstream escapement of hatchery summer-run, and a virtual elimination of hatchery winter-run escapement upstream (Figure 7).

Temporary loss of the mesh curtain during flow events in some years permitted moderate numbers of adults (<200) to bypass the fishway until the mesh was replaced. A more serious failure occurred in 2003 when a small passage way opened up through interstitial spaces between boulders in a rock bank at one side of the falls and nearly 700 hatchery fish passed upstream by that route. Despite the setbacks, the escapement of hatchery summer-run was reduced from an average of over 2300 from 1982-1996 to less than 240 from 1997-2003. Because hatchery winter-run are not successful at jumping the falls (Bradford et al. 1986), we presume the passage denial of those fish to be 100% effective (winter conditions preclude confirmation by snorkel surveys).

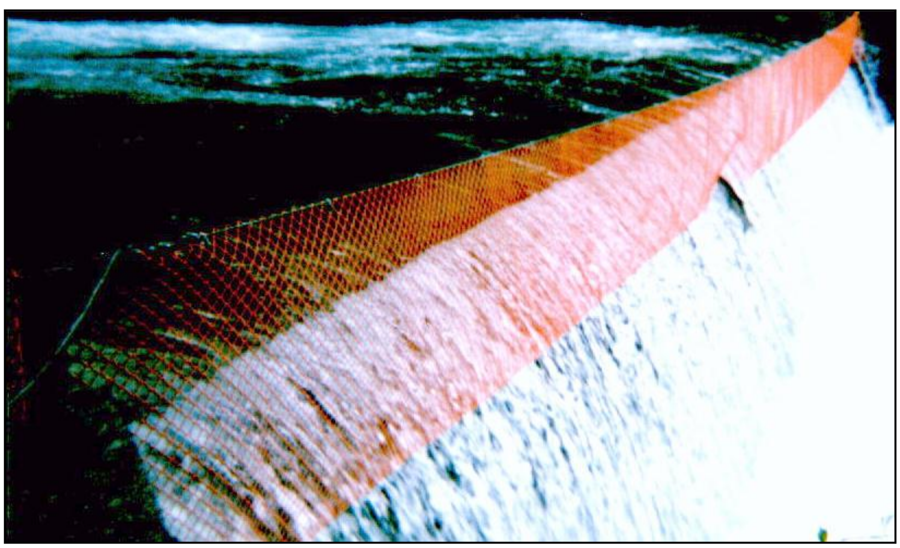

Figure 6. Plastic "construction barrier" mesh suspended from cable over the top of the partial barrier falls below Kalama Falls Hatchery to prevent summer steelhead from jumping the falls and bypassing the fishway. The entrance to the fishway would be directly below the lower left corner of the photograph.

Given the number of years in which hatchery adults had high levels of spawning escapement (Figure 7), some level of genetic introgression from the hatchery stocks into the wild populations might be expected. However, genetic analyses of the 1988-1993 brood years of the hatchery and wild stocks showed relatively discrete population structure based on allozyme profiles (Sharpe et al. 2000). While those data should not be construed as evidence that the wild stocks remain genetically "pure", they do suggest that a combination of factors acted to avert homogenization in spite of the high potential for gene flow. Two factors that could have reduced gene flow are the partial reproductive isolation due to earlier spawn timing of the hatchery stocks (Leider et al. 1984) and the greatly reduced ability of the hatchery stocks to produce returning adult offspring relative to that of the wild stocks (Leider et al. 1990; Hulett et al. 1996).

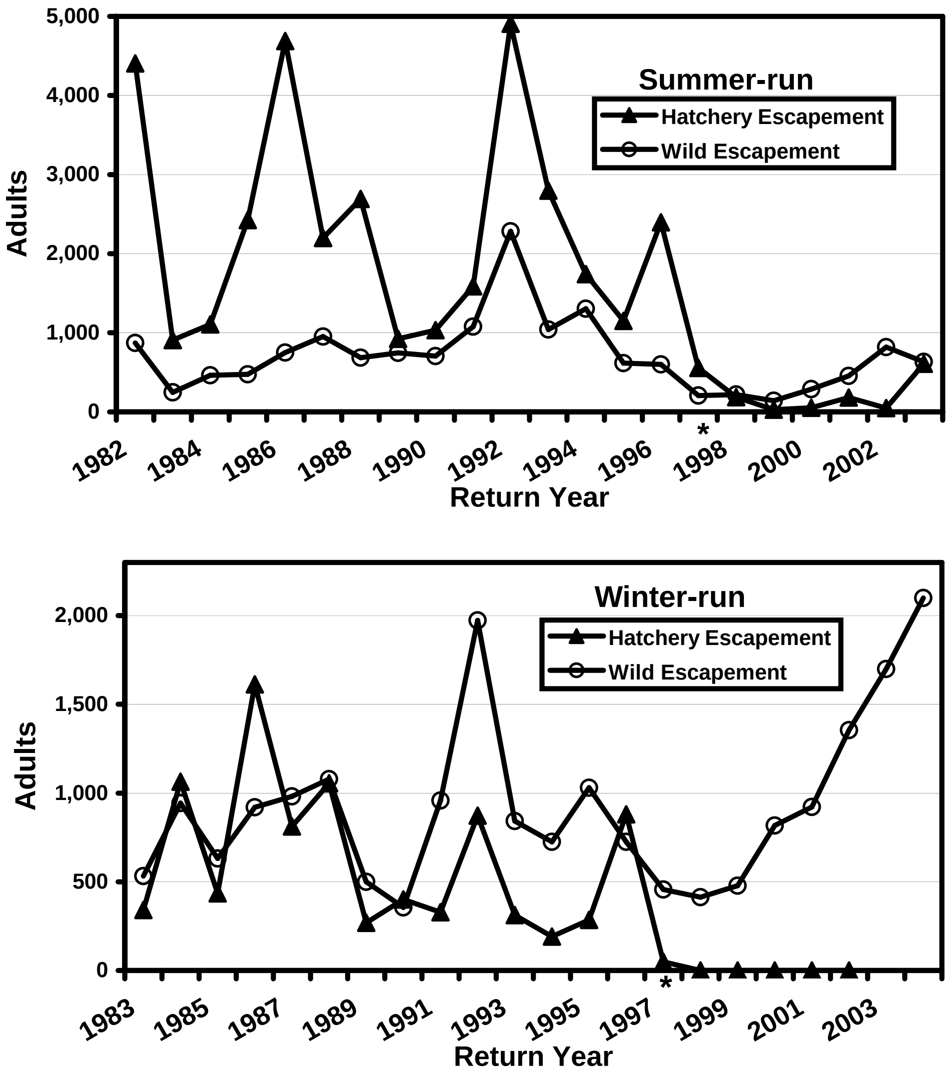

Figure 7. Spawning escapement of summer-run (top panel) and winter-run (bottom panel) steelhead above Kalama Falls Hatchery for the 1982-2003 summer-run and 1983-2004 winter-run return years. Asterisks on the return year axes mark the cessation of passage of hatchery adults above the hatchery in 1997.

Wild Broodstocks

The production and evaluation of steelhead wild broodstock hatchery programs on the Kalama River is the most recent change in management strategies of Kalama steelhead. Summer-run and winter-run programs were both initiated in 1998, and have resulted in five years of smolt releases for summer-run (2000-2004) and six for winter-run (1999-2004). The main impetus for these programs was to rigorously assess the efficacy and risks of using local wild broodstock for hatchery steelhead programs (see Sharpe et al. (2000) and Hulett et al. (in press) for program details). However, both programs also provide harvest in addition to that from the ongoing hatchery programs using the traditional non-local origin stocks. The addition of these stocks affect management and fisheries in the Kalama in a number of ways, including fish passage protocols, harvest regulations, and fishery characteristics.

The primary objective of the summer-run wild broodstock program is to compare the reproductive success of its returning adults to that of the wild Kalama adults when both spawn naturally in the Kalama River. The experimental design calls for equal numbers of wild broodstock hatchery adults and wild adults to be passed upstream of Kalama Falls Hatchery. However, those two groups of fish must have equal opportunity to spawn for the comparison of their reproductive success to be biologically meaningful. Thus, because of the research needs, we implemented an unusual regulation that requires the release of all steelhead (including hatchery adults) caught in the mainstem and tributary waters above Kalama Falls Hatchery. However, all hatchery steelhead are still subject to harvest in the lower river, and wild broodstock returns in excess of those needed to match wild numbers passed upstream are “recycled” downstream to reenter the fishery.

Adults from the winter-run wild broodstock program that return to the trap at Kalama Falls Hatchery are all trucked downriver to be passed through the lower river fishery again, similar to the protocol for the non-local hatchery stocks. Because the wild stock has a much later return time than the non-local winter stock, the duration of the winter-run fishery is greatly extended by the addition of the wild broodstock component. The fishery on the non-local stock is conducted mainly in December and January, whereas the wild broodstock program contributes to harvest from February into May.

Another feature of the summer-run wild broodstock evaluation is the need to understand whether or to what extent resident rainbow trout contribute to the production of anadromous *O. mykiss* in the Kalama River. Other studies of reproductive success have found that surprisingly large numbers of returning anadromous adults do not appear to have come from the anadromous parents that previously spawned in that basin (e.g., Blouin 2003). The working hypothesis is that resident rainbow trout may be contributing to the production of anadromous offspring. In an attempt to test that hypothesis, we are collecting tissue samples for DNA analyses that could tell us if any of the sampled resident fish were a parent to any of the anadromous fish we sample to conduct the reproductive success study. Based on observations during snorkel surveys, it appears that the majority of the resident trout are found in the upper basin (closed waters), so they may not contribute much directly to fishery benefits. They may, however be an important component of the overall life history diversity of *O. mykiss* in the Kalama, and perhaps contribute to the stability and persistence of the anadromous population.

Summary

Through several decades of changes in management approaches, the Kalama River continues to support productive and popular harvest fisheries on hatchery steelhead, as well as relatively healthy wild populations of steelhead and resident rainbow trout. Factors believed to contribute to this success include: the intent and ability to manage and monitor hatchery and wild stocks separately, the provision of closed water sanctuary habitat, the ability to control the distribution of returning hatchery adults, and a comparative wealth of information on the biology of the local populations due to rigorous monitoring and evaluation. A healthy dose of good fortune also came into play, in that the wild steelhead stocks maintained genetic distinctness despite the many generations of potentially disastrous hatchery introgression from non-local, domesticated stocks.

Acknowledgements

We thank the crew and supervisors of the Kalama Falls Hatchery for their support and patience in dealing with the meddling of biologists on the hatchery grounds. This work was supported by Mitchell Act funding administered by NOAA Fisheries in cooperation with the Washington Department of Fish and Wildlife.

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Apache Trout—Restoration, Recreational Fisheries, and Species Recovery

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ABSTRACT— The Apache trout is listed as threatened under the Endangered Species Act (ESA). Past recovery efforts have led to improvement in Apache trout populations in the White Mountains and on the lands of the White Mountain Apache tribe in eastern Arizona. In 2003, the U.S. Fish and Wildlife Service (USFWS), White Mountain Apache Tribe (WMAT), U.S. Forest Service (USFS), Arizona Game and Fish Department (AGFD), and Trout Unlimited formed an informal Apache Trout Recovery Partnership (Partnership) to fund and implement conservation work. While many restoration projects for Apache trout have occurred over the past 35 years, the recent efforts of the Partnership have focused on an approach that combines species recovery concerns with a long term goal of developing robust Apache trout recreational fisheries. The Partnership's conservation actions are guided by the Apache Trout Recovery Plan (USFWS 1983) developed by the Apache Trout Recovery Team (Recovery Team) pursuant to the ESA listing for the species. A revision of the Recovery Plan is in draft format, and is expected to be released in the Federal Register in 2005. In conducting current Apache trout restoration activities and in planning future activities, both the members of the Recovery Partnership and the Recovery Team are addressing issues that require balancing native trout recovery activities and the management of recreational fisheries based on introduced trout species. This paper provides an overview of Apache trout restoration efforts and the implications for recreational fisheries in the future.

Introduction

The Apache trout, one of the first native fish to be placed on the federal Endangered Species Act (ESA) list, is an important part of Arizona's natural heritage and recreational fisheries. Many species conservation activities have occurred over the last 35 years. In 2003, the U.S. Fish and Wildlife Service (USFWS), White Mountain Apache Tribe (WMAT), U.S. Forest Service (USFS), Arizona Game and Fish Department (AGFD), and Trout Unlimited formed an informal Apache Trout Recovery Partnership (Partnership) to fund and conduct conservation work. The Partnership is supported by a national grant from the National Fish and Wildlife Foundation which is matched by state and local resources (non-federal dollars and/or in-kind services). The work conducted by the Partnership under the grant has direct implications for restoring depleted and extirpated fish populations, de-listing the species under the ESA, and developing robust recreational fisheries.

The grant work is guided by a recovery plan for Apache Trout (USFWS 1983) authored by a Recovery Team pursuant to the ESA listing. The Partnership has used the recovery plan to guide implementation of recovery projects and to address many of the issues that are common to the balancing of native trout recovery and introduced trout that support recreational fisheries.

Species Description and Threats

The Apache trout is a native species found only in Arizona. These golden fish, with olive-green back and dorsal fins and sparse black spotting, inhabit the streams of the White Mountains. Although still formally identified as a separate species (Oncorhyncus apache), the Apache trout will likely soon be identified as a subspecies of Gila trout by the American Fisheries Society due to their close evolutionary relationship (Joseph Nelson, Committee on Names of Fishes, personal communication). Both Apache and Gila trout are more closely related to rainbow trout than to cutthroat trout, and probably represent the earliest living branch of ancestral trout associated with the Gulf of California. These ancestral trout are believed to have ascended the Gila River Basin via the Colorado River about 500,000 to 1 million years ago (Behnke 2002).

The maximum known age for Apache trout is 6 years. Most fish reach maturity in three years (6 to 9 inches). Native populations are presently restricted to clear, cool, high-elevation mountain streams that flow through meadows and coniferous forests, upstream from natural and man-made barriers. The fish may grow much larger (up to 24 inches and 6 pounds) when introduced in lakes rather than in their small stream habitat. Natural lakes were in the historic range of the species. The current lake dwelling populations were developed to support recreational fisheries only.

In the late 1800s, substantial harvest of Apache trout was documented in its historical stream range. The impacts of human settlement rapidly eliminated or reduced most populations within a span of about 50 years (Behnke and Zarn 1976; Harper 1978). By the time the subspecies was officially described and then listed under the ESA in the 1970's, the Apache trout was found in fewer than 30 miles of the 600 miles of stream that it originally occupied on the Fort Apache Indian Reservation and the Apache-Sitgreaves National Forest (Carmichael et al. 1993). Although the exact historic distribution of the Apache trout is not known for certain, there is no doubt that widespread introduction of brook, brown, and rainbow trout and loss of habitat due to land-use practices including livestock grazing, logging, road construction, and water diversions drastically affected their former native range (Behnke 2002). Although many of the threats have been addressed, further conservation work remains to fully restore the species and perhaps modify Apache trout recreational fisheries today.

Road to Recovery

Apache trout recovery involves a variety of actions including construction of fish barriers to prevent encroachment of non-native species, improvement of riparian habitats, control of livestock use, removal of non-native fish, and reintroduction of populations to historic stream habitats (Springer 1999). These actions are typical of similar native fish efforts in many other areas. While the species is probably more secure and there are more recreational fishing opportunities for Apache trout than when it was first listed, the improvements occurred at an uneven rate over many years. A brief timeline developed by AGFD provides a glimpse of the challenges faced by the trout and those who have worked to restore them:

1940s-1950s - White Mountain Apache Tribe initiated Apache trout conservation efforts when the only known populations existed on the Fort Apache Indian Reservation. On March 24, 1955 the tribe closed all streams within the boundaries of the Mount Baldy Wilderness Area to fishing. Subsequently, other streams deemed important to Apache trout conservation were also closed to fishing.

Early 1960s - Fishery surveys were conducted by the USFWS and the AGFD in cooperation with the WMAT to determine the Apache trout status. A controlled propagation program was initiated as part of the federal and state Apache trout recovery effort in 1963. During this period, fish barriers were constructed on several streams to prevent upstream migration of non-native trout. Several streams were renovated to remove non-native rainbow trout, brown trout, and/or brook trout. Pure Apache trout were stocked into streams following renovations.

1966 - Despite early conservation efforts, Apache trout were considered endangered under the Federal Endangered Species Preservation Act of 1966 and became federally protected with passage of the Endangered Species Act in 1973.

1975 - The Apache trout was one of the first species to be down-listed from endangered to threatened after re-evaluation of its status. The down listing included a 4(d) rule that allows the State to authorize selective angling opportunities. Hatchery-reared fish were stocked to establish angling opportunities.

1979 – A recovery team consisting of federal, state, and tribal agencies prepared an initial recovery plan for Apache trout pursuant to the ESA listing. The plan was updated in 1983.

1983-87 – The Old Pueblo Chapter of Trout Unlimited obtained private sector national grants and undertakes habitat restoration activities in the Black River watershed to aid Apache trout recovery.

1994 - The AGFD in cooperation with the USFS developed a habitat improvement plan to install approximately 30 miles of riparian fencing to protect key stream segments from livestock and/or elk damage.

2002 – 2004 -The USFS in cooperation with the AGFD completes the National Environmental Policy Act (NEPA) process for implementing a variety of recovery actions including approval of a major restoration effort on the Black River that could eventually support a major recreational fishery.

2003 – The Arizona Council of Trout Unlimited makes Apache Trout Recovery a top priority. The Council in conjunction with TU national develops a major funding and education campaign for Apache trout. The Council joins public and private partners to form the Apache Trout Recovery Partnership to implement restoration activities funded by new national grants.

Fisheries Management and Endangered Species Recovery

The issues surrounding sport fish management and endangered species can be controversial. Apache trout restoration highlights some of the potential conflicts, because AGFD, like many other fishery agencies, has a dual responsibility to conserve listed species as well as other non-game fishes and sport fish. As a first step in recognizing the importance of Apache trout as a native species, the White Mountain Apache Tribe closed all fishing for the trout in the 1950's in the Mt Baldy area. There wasn't any resistance from anglers at the time because the species had been reduced to less than 30 miles of stream habitat and it was clear that the action was warranted. Nevertheless, the WMAT also recognized the value of Apache trout as a recreational fish and pioneered the development of lake fisheries for large fish in the 1970's. Similarly, the USFWS, AGFD, and USFS were faced with balancing the needs for native species restoration with demands for recreational fishing opportunities. Early in their recovery efforts, these agencies recognized the value of Apache trout as a sport fish and used it to boost public support for endangered species recovery. This strategy was effective, but also has created additional challenges in communicating the differences between restoration and recreational objectives.

Unlike the issues generated by the impacts of introduced sport fish on endangered non-game species, Apache trout conservation involves the recovery of an endangered species that is an important sport fish. Like other native trout, the Apache's status as both a unique environmental resource and a recreational commodity should make the balancing of these issues easier to resolve. However, when other non-native trout species also become part of the restoration/recreation equation, communication of the issues to the sport fishing community and the larger public can become difficult and confusing.

Species Recovery Plans

Endangered species recovery plans must address the scientific and technical issues related to conserving a species and preventing its extinction. Typical recovery issues are population viability assessments, need for metapopulations, minimum population sizes suitable habitat criteria, extinction risks, and other complex assessments. Revision of the existing Apache Trout Recovery Plan began in 2000, and is still underway. Conceptually, the new plan should expand and improve the scientific basis of the 1983 recovery plan. Besides refining criteria that will be needed for ESA de-listing, the revised recovery plan could also improve on the 1983 plan by clarifying and addressing the balancing of native trout restoration with the introduced trout that support recreational fisheries.

Besides addressing ESA scientific and technical issues, recovery planning can provide a forum that improves public understanding of the broader issues. For Apache trout, the biggest opportunity to improve public understanding of the broader issues is to identify a long term vision of a recovered Apache trout species that expands the diversity of fishing opportunities in Arizona. Most anglers are well aware of Apache trout recreational potential through the lake fisheries that have been established over the years. Much of the remaining angler uncertainty involves recreational opportunities on recovery streams. This uncertainty could be alleviated by identification of Apache trout streams that would not only meet ESA delisting requirements, but also support robust recreational fisheries.

Restoration and Recreation

Apache trout recovery, like all native trout recovery, revolves not only around the question of how recovery is conducted, but also why certain actions are undertaken, and the long-term ramifications of those actions. Clear and concise rationale for conservation actions is essential in recovery planning. The Partnership has played a key role in implementing restoration projects, but it was not designed to be a forum for stakeholders to address complex and controversial issues. These kinds of policy issues can only be debated in policy forums such as the public comment periods on proposed government actions that is provided under National Environmental Policy Act (NEPA). A major test for the balancing of Apache trout restoration with recreational fishery interests occurred during a NEPA review that occurred from 2002-2004.

The basic approach to Apache trout recovery is similar to other native trout, and includes removing introduced trout species from recovery streams and replacing them with pure Apache trout. The streams that will receive this treatment occurred on Forest Service lands and were subject to a NEPA review. There was broad support for the Apache trout recovery proposal from the angling public during the NEPA process. Two factors were prominent in angler support during the NEPA process: 1) a portion of the angling public had detailed knowledge of the species recovery process through the Apache Trout Recovery Partnership; and, 2) many anglers had past positive fishing experiences with Apache trout. Although a few anglers expressed dismay over loss of fishing opportunities for non-native trout, most anglers understood both the species recovery reasons and the potential angling benefits of the proposed actions.

Balancing Native Fish Recovery and Recreational Fisheries

Unlike some other native trout recovery situations, the current Apache trout recovery program has not generated an unusual amount of conflict among recreational anglers. Although there was some minor dissent during the NEPA process, much of the support can be traced to the long history of Apache trout recovery and the active promotion and development of the species as a sport fish. Nevertheless, there still have been tradeoffs and compromises between native fish advocates and recreational fisherman. Recreational fishery stocking and protection of native fish, regulations for small stream fisheries, and conversion of non-native fisheries to native Apache trout are just some of the issues that will continue to be addressed.

In dealing with these issues, the underlying technical questions revolve around what is biologically necessary (and feasible) to recover native trout species, and recreational demand for the resource. Sound science and current information should always provide the framework for this decision-making, but our knowledge base is often incomplete. When this happens, science is combined with human value judgments and recovery efforts can be influenced by these societal values, and arguably, may result in differing objectives or conservation and recovery emphasis. The Partnership that was formed, and the associated grant that was awarded, allows the Partners to work towards a common goal with open communication of issues, identification of threats and associated conservation needs, acquisition of research or contract work necessary to accomplish the goals, and assistance in communicating with the angling public during the process. There is also little doubt that development of recreational fisheries for Apache trout has laid the necessary foundation for continued steps forward.

The progress in the Apache trout recovery program has proven that native fish recovery, the Endangered Species Act, and recreational fisheries have much in common. There is potential for advocates of different viewpoints to work in harmony because they ultimately have the same interests in healthy watersheds and fish populations. The good news for Apache trout and other native trout species is they are great sport fish and a valuable recreational resource.

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Balancing the Management of Native and Introduced Species

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Good afternoon!

Thank you for the opportunity to address such a prestigious group of fisheries professionals and for the privilege to participate in today's panel discussion on "Balancing the Management of Native and Introduced Species."

I am Bob Jacklin, outfitter and guide for the last thirty-five years in West Yellowstone, Montana. For forty years, I have made my living by selling fishing tackle. I am also a charter member of the Federation of Fly Fishers (FFF), President of the Western Rocky Mountain Council of the FFF, a long-time member of Trout Unlimited, of the Theodore Gordon Fly Fishers, and of the Anglers Club of New York City. Most of all, however, I'm a proponent of safeguarding our cold water fisheries and our national treasures like Yellowstone National Park and the surrounding waters such as the Madison River, the Henry's Fork of the Snake River, the Yellowstone River, and many others. My love for trout and trout fishing started long ago. As an eight- or ten-year-old, I was captivated by the romance and the tradition of trout fishing, when I saw firsthand the lure of "Opening Day of the Trout Season" in my home state of New Jersey. The fishermen were decked out in brown canvas or tweed jackets, in some cases with ties, including their lucky fishing hats, wicker creels, chest waders, and bamboo fly rods. They were nearly all well-dressed anglers. By the time I was seventeen, I was tying and supplying several tackle shops with custom flies for their dapper customers.

Today, I owe everything I have to trout and fly-fishing. For me, it is much more than money or self-aggrandizement. I love fly-fishing for trout; it is my first love and a confirmed way of life. As one who is entering his senior years—I will be 60 years young this January—I still have all the vigorous passion and love for the romance, the tradition, and the history connected with fly-fishing for trout, and I have the drive to leave our fisheries better than I found them.

This afternoon, therefore, I would like to present several comments and questions that I hope will stimulate some productive discussion, for I have spent many years observing fisheries and talking to fisheries people about resource management, as well as participating in stream and habitat improvement. My thoughts and comments are in keeping with today's program of balancing our native and introduced species. First, however, let me tell you that I have spent almost my entire life studying trout and trout fisheries. Although I have no formal education in the fisheries management field, I have studied much on my own. I'm self-taught, as it were. Furthermore, I am willing to learn and to keep an open mind.

Some years ago, the late Lee Wulff, one of my mentors in fly-fishing, for whom I have the greatest respect, presented a paper at Wild Trout Two, in 1979, which, by the way, I attended. As Lee observed then, finding a beautiful pool in a beautiful stream and have it devoid of fish is a fisherman's nightmare. Finding that same pool filled to its potential with hard-to-catch trout is a welcome challenge. Today, Lee's comment fits in with my main question for you: What are we managing for? Do we have a goal, a plan, and an objective for the fisheries in question? Have we formulated a fully articulated mission statement to guide us along that course? Is part of that plan designed to accommodate the recreational needs of the public? If so, great. If not, then why not? My question for you and your respective state, federal, or other agencies is, what is your goal? If you have a mission statement, are you making progress towards its goals? Are these goals realistic? Does the mission statement allow introduced species to have a place in our fisheries management? We must provide and use to their full advantage these introduced species. These trout, though non-indigenous, are what I term “naturalized natives” where they are self-sustaining and providing good recreational opportunities for the sport fishermen.

I thank God that, in my lifetime, I have seen and been privileged to participate in three different managements tools intended to provide sport fishing for the public. First, is Put-and-Take trout fishing, where we put the fish in and then take them out. This option does provide some good recreational value, but it should only be used where there are no other options. The second tool is the most useful and cost-effective means of managing our fisheries: Manage for All-natural Reproduction, using the indigenous trout for that purpose. I consider myself very lucky to have been shown a wild brook trout fishery in my home state of New Jersey, when I was just thirteen years old. That wild trout fishery in New Jersey , considered to be a heritage strain, still exists today, and it provided me with many years of valuable quality recreation and the chance to study and observe the movements of wild fish in their natural habitat. This second management tool should be used wherever we can as long as the fishery will sustain itself and provide recreational opportunities for mankind and subsistence value for our wildlife. The third management tool I have observed is what I label “Semi-Wild.” I have seen this tool used very effectively for many years in the state of Idaho—for example, on the Henry’s Fork of the Snake River and on other waters in this region. This management tool is nothing more then stocking fingerling size trout to supplement and to enhance populations where the natural reproduction is not strong enough to supply sufficient numbers of catchable-size trout. This supplementation of fingerling size fish allows a more natural answer to stocking by allowing the smaller fish to filter into the eco system in a more natural way with much less negative impact to the total fishery. This Semi-Wild management tool is obviously very cost effective compared to the Put-and-take option, and it provides a more natural approach to balancing the management of our native and introduced species and still provides the public with a quality angling experience.

The key words here are: 1) Balancing, 2) Keeping an open mind, 3) Using good common sense, 4) Having realistic goals with a well-thought-out mission statement, and 5) Avoiding the implementation of blanket policies that, in most cases, do not yield truly sought after or practical solutions.

I realize that my views may differ from those of the National Park Service or the U.S. Fish and Wildlife Service or those of your home state or agency. Like Lee Wulff, however, I devoutly believe that having that beautiful pool filled to, or balanced to, hold the maximum amount of catchable-size trout to temp the angler and to provide ample nourishment for our wildlife is a praiseworthy and attainable goal. We must do all we can to safeguard our headwater streams, the home range of native indigenous species, to reestablish and protect our native species wherever we can, to balance our fisheries, and to use these introduced species to their full advantage. In some cases, these introduced species have adapted quite well and should be treated like the “naturalized” gems they are.

Again! Thank you for the opportunity to present my views on balancing our fisheries.

God Bless!

Bob Jackl

Wiscoy Creek, New York; A 60-year Transition from Put-and-take Stocking to Wild Trout Management

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ABSTRACT—Wiscoy Creek currently supports one of New York's premier wild brown trout (*Salmo trutta)* populations. From 1940 to 2001, the stream experienced a management transition from liberal harvest strategies and high stocking levels to restrictive harvest regulations and the elimination of stocking. Surveys in 20 individual years showed the abundance of wild brown trout increased from less than 200 fish/mi to greater than 1,700 fish/mi. From 1940-1944 summer water temperatures exceeded 75° F and few wild trout were collected. By 1968, greater numbers of wild trout were present. To maximize the contribution of wild trout, a special regulation section was established and hatchery stockings were eliminated in that section. Within three years wild trout abundance had doubled in the special regulation section, while abundance dropped in the control section. In 1994 a catch and release regulation was applied on one mile of Wiscoy Creek. By 2001, wild brown trout abundance averaged 1,707 fish/mi, with some stations in the catch and release section supporting over 3,000 fish/mi. Several factors likely contributed to the increased abundance of wild trout: improvements in water quality, decreased summer water temperatures, cessation of stocking, restrictive harvest regulations, decreases in fishing pressure, and voluntary decreases in angler harvest. This paper examines the roles these factors have played in improving Wiscoy Creek's wild trout population over the last 60 years.

Introduction

Wiscoy Creek, located in southern Wyoming County, NY (Figure 1), supports one of the most abundant wild brown trout (*Salmo trutta*) populations in New York State (Evans and Cornett 2002). In 2001, there was an estimated average wild trout biomass of 155 lbs/ac. The stream, which has an average summer width of 30 ft and an average gradient of 35 ft/mi, flows for 22 mi before joining with the Genesee River. The upper 17 miles are considered the best trout water. Abundant spring water influence due to deep glacial gravel deposits underlaying the watershed (Miller and Staubitz 1985) help to keep the stream's temperature in the optimum range for brown trout growth and survival (Bachman 1991). Wiscoy Creek is a highly productive stream (specific conductivity: 360-390 μmho/cm) flowing through a mixture of agricultural and forested landscapes. Stream flows in the late summer average 30 cfs. Wiscoy Creek is located approximately an hours drive from the cities of Buffalo and Rochester. The stream is popular with anglers from across western New York, supporting an estimated 4,380 angler days per year (Evans and Cornett 1998).

Brook trout (*Salvelinus fontinalis*) were the native trout species in Wiscoy Creek. They are still encountered occasionally in the stream's upper section and in several tributaries. When the area was originally settled, brook trout populations declined significantly due to the clearing of surrounding forests, elevated stream temperatures, water pollution from local dairy processing plants

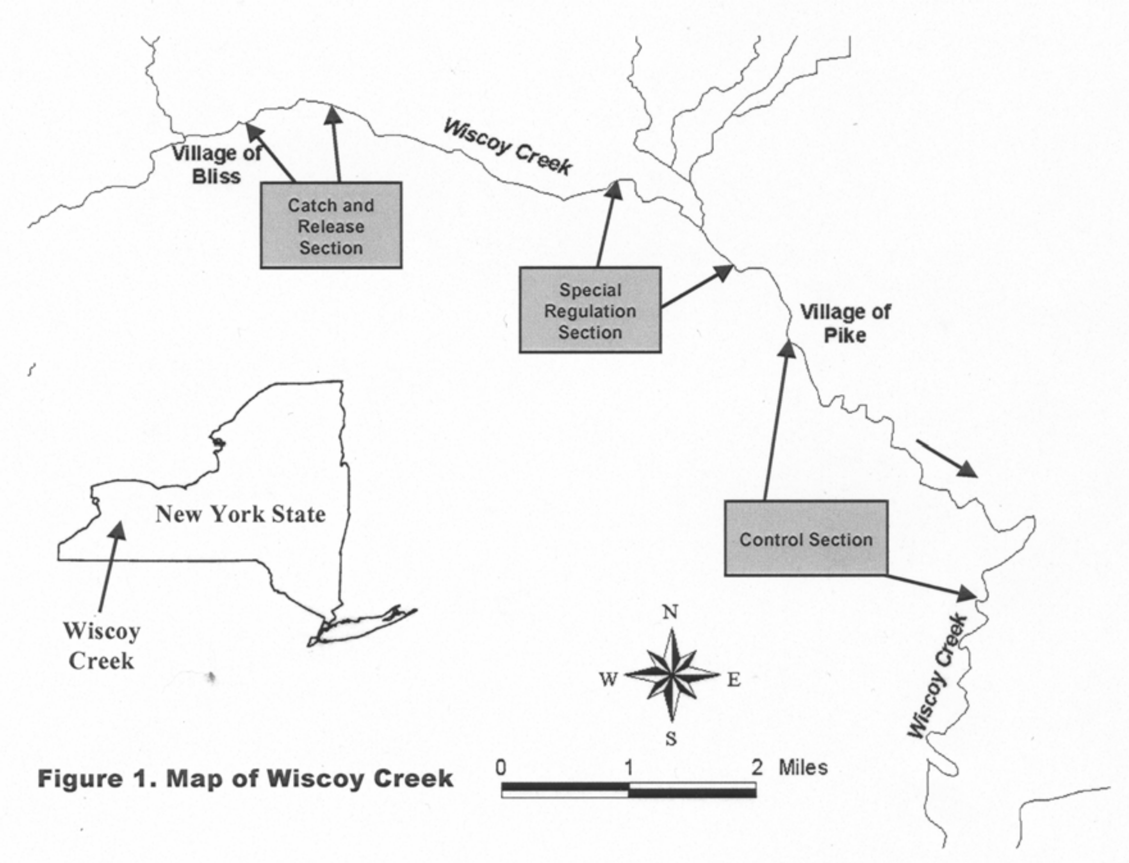

Figure 1. Map of Wiscoy Creek

and possibly from competition with brown trout. The earliest stocking records for Wiscoy Creek indicate brown trout fingerlings were first stocked in 1889.

New York State began purchasing Public Fishing Rights Easements in 1936, which allowed anglers to access the bed and banks of trout streams. The first such easements were purchased in 1936 on Wiscoy Creek and a major tributary, East Koy Creek. Today over 12 mi of Wiscoy Creek and 13 mi of tributaries are permanently open to anglers because of these easements.

Trout populations in Wiscoy Creek have been intensively studied over four main time periods: 1940-1944, 1966-1974, 1978-1981 and 1988-2001. Angler-use studies have also been conducted in the 1966-1974 and 1988-2001 time periods. Since 1966 several management regimes utilizing different sets of fishing regulations and trout stocking policies have occurred on Wiscoy Creek. Major changes occurred in 1968 when an artificial lure only, 12 in size limit, 3 trout/day section was established, in 1972 when all stocking of hatchery trout in the study section ceased, and in 1994 when a catch and release section was established. Table 1 lists the regulation and stocking history for several time periods from 1966 through the present.

Table 1. Wiscoy Creek fishing regulations and trout stocking, 1966-2004.

Time Period	Regulations and stocking
1966-1967	Entire stream: No size limit, 10/day, 10 miles stocked with 15,500 brown trout yearlings.
1968-1971	Special reg section: 12” size limit, 3/day, art. lures only. Rest of stream: no size limit, 10/day. Special regulations section not stocked.
1972-1977	Special regulations section: 10” size limit, 5/day, art. lures only. Rest of stream: no size limit, 10/day. Stocking removed on all study sections.
1978-1981	Special regulations section: 10” size limit, 5/day, art. lures only. Rest of stream: 9” size limit, 5/day. No stocking.
1982-1993	Special regulations section: 10” size limit, 3/day, art. lures only. Rest of stream: 10” size limit, 3/day. No stocking.
1994-2004	Special regulations section removed in 1994. New catch and release section established in 1994. Rest of stream: 10” size limit, 3/day. No stocking.

Methods

Changes in the Wiscoy Creek brown trout population and fishery were examined by searching New York State Department of Environmental Conservation file data and sampling reports. Surveys in the 1940-1944 period utilized both angler catch data (1943 and 1944) and electrofishing data (1940 and 1941). The exact methodology for surveys in this time period could not be ascertained. However, for the purposes of this project, trout population estimates are assumed to be valid. The primary reason for the 1940-1944 study was to assess the values of different stocking regimes and techniques on angler catch. Values of angler pressure were not collected.

Data from the 1966-1974 time period included both angler contact surveys in 1966, 1972, and 1974, and electrofishing data in eight of the nine years. Data from the 1978-1981 period included electrofishing surveys for all four years, with no angler contact data. Surveys in the 1988-2001 time period included electrofishing in four years, an angler contact survey in 1997, and angler diary programs in 1997 and 2001. Electrofishing in all surveys from 1966-2001 utilized two pass population removal methodology (Ricker 1975, Van Deventer and Platts 1989). The exact location of sampling sites varied over time. Population estimates stated for trout throughout the rest of this report are for yearling and older trout, as no attempt was made to estimate young-of-year populations.

Results

1940-44

In August of 1940 and 1941, biologists utilized electrofishing to sample trout populations at five sites in the mid to lower Wyoming County sections of the stream, near the Village of Pike. Sampling both years indicated that there were about 500 brown trout/mi of stream, however researchers did not determine what percentage of these fish were of wild origin (Heacox 1943). Angler creel surveys conducted in 1943 and 1944 determined that about 90% of the trout caught by anglers were fin-clipped hatchery fish (Heacox 1944). Since hatchery brown trout can be as much as four times more catchable by anglers than wild brown trout (Engstromg-Heg and Hulbert 1982), the 10% wild brown trout component for the recreational fishery may have reflected an actual abundance of 50/mi to 200/mi for wild brown trout.

1966-74

Electrofishing in 1966 occurred in both public and posted sections of streams with estimates for trout numbers roughly 2-3 times as high in the posted unstocked sections (Pomeroy 1975). Eight electrofishing sites were established beginning in 1968, four in the special regulation section and four downstream of the Village of Pike (referred to as the control section) (Figure 1). In 1966 there were an estimated 248 wild brown trout/mile in the control section and 341 wild brown trout/mi in what would become the special regulation section. By 1971, the estimated number of wild brown trout in the control section was 192/mi, while the estimated population in the special regulation section had increased to 701 wild brown trout/mi. The average estimated number of wild brown trout in the control section from 1972-1974 was 419/mi, while the estimated number in the special regulations section for that time period was 669 trout/mi (Table 2) (Pomeroy 1975). Based on the three years in which angler contact surveys were conducted in this time period, angler use dropped considerably. The estimated pressure in 1966 was 966 hrs/ac. In 1972, pressure was estimated at 461 hrs/ac and in 1974 it was estimated at 479 hrs/ac (Pomeroy 1975).

Table 2. Wild brown trout population (number/mi) estimates for yearling and older fish in Wiscoy Creek, 1940-2001.

Year (s)	Control section	Special regulation section[1]	Catch and release section[2]
1940-41	50 to 200	---	---
1966	248	341	---
1968	240	545	---
1969	354	607	---
1970	201	549	---
1971	192	701	---
1972	217	406	---
1973	421	683	---
1974	619	918	---
1978	315	629	---
1979	276	459	---
1980	476	650	---
1981	421	---	---
1988	1,680	1,570	---
1991	1,515	1,601	---
1992	---	---	1,609
1993	---	---	2,478
1997	850	886	2,686
2001	1,256	1,452	2,897

[1] Regulation section established in 1968 and removed in 1994.

[2] Catch and release section established in 1994.

1978-81

Stocking of hatchery trout in the section studied ceased in 1972, thus subsequent estimated trout populations studied in the remainder of this report can be assumed to be fish of wild origin. In 1978, the special regulation section had an estimated average of 629 brown trout/mi, while the control section averaged 315 brown trout/mi. The special regulation section in 1979 had an estimated average of 459 brown trout/mi and the control section had an average of 276 brown trout/mi. By 1980, the special regulation section average had increased to 650 brown trout/mi, while the control section had also increased with an average of 476 brown trout/mi. The 1981 estimate for the control section was 421 brown trout/mi (Table 2) (NYS DEC file data).

1988- 2001

In 1988, seven electrofishing sites, roughly corresponding to the sites sampled in 1968-1974 and 1978-1980, were sampled. The average estimated number of brown trout in the control section was 1,680/mi and in the special regulation section the estimated number was 1,570/mi (Table 2) (Evans 1990).

Eight electrofishing sites were used in the 1991 sampling, with three sites located in the special regulation section and five in the control section. The average estimated number of brown trout in the control section was 1,515/mi and the average number in the special regulation section was 1,601 brown trout/mi (Table 2) (Evans 1992). In 1992 and 1993, two sites in what would become the catch and release section were electrofished. The average number of brown trout/mi in this section was estimated to be 1,609/mi in 1992 and 2,478 in 1993 (Table 2) (Evans 1995).

In 1997, six electrofishing sites were sampled in the former study sections and two sites were sampled in the new catch and release section. In the control section the average estimated number of brown trout was 850/mi and the average number for the former special regulation section was 886 brown trout/mi. In the catch and release section, there were an average estimated 2,686 brown trout/mi (Table 2) (Evans and Cornett 1998). An angler contact survey, conducted from April through June, was completed in 1997. This survey showed there were an estimated 4,380 angler days (355 hrs/ac) on Wiscoy Creek for the 1997 season. The average angler catch rate was 0.70 trout/hr. In 1997, angler diarists reported making 411 trips, catching 1,600 brown trout, for an average catch rate of 1.27 trout/hr (Evans and Cornett 1998).

Five sites were electrofished in the control section in 2001, while one site was surveyed in the former special regulation section. Two sites were sampled in the catch and release section. The average estimated number of brown trout was 2,897/mi in the catch and release section. In the control section there were an average of 1,256 brown trout/mi and at the site in the former special regulation section there were an estimated 1,452 brown trout/mi (Table 2). In 2001, angler diarists reported an average catch rate of 1.20 trout/hr (Evans and Cornett 2002).

Discussion

The 1940-1944 sampling indicated that Wiscoy Creek was a heavily stocked, heavily harvested stream. Wild trout were uncommon, likely due to high water temperatures, which reached the upper 70’s°F. Fish species indicative of warm water such as creek chub (*Semotilus atromaculatus*), central stoneroller (*Campostoma anomalum*), and redside dace (*Clinostomus elongatus*) were abundant (Heacox 1944). The Wiscoy Creek watershed was being intensively farmed, with the pasturing of cattle in riparian areas a common practice. Riparian vegetation and stream shading were limited. Water withdrawal for irrigation may also have been impacting trout populations at this time.

By 1966, electrofishing results indicated that wild trout populations were much higher in private, unstocked, lightly fished sections of the stream than in the stocked, public water. Fishing pressure was relatively high at over 900 hrs/ac. Through the application of restrictive fishing regulations, biologists hoped to maximize the Wiscoy Creek wild trout fishery (Pomeroy 1975). In 1968, a one mile long section of the stream was restricted to artificial lures only, with a 12 inch minimum size limit and a creel limit of 3 trout/day. The special regulation section was no longer stocked with trout. By 1971, the numbers of wild trout had doubled in the special regulation section to more than 600/mi, while abundance had declined in the lower, control section. Pomeroy (1975) attributed the doubling of trout in the special regulation section to allowing more trout to reach reproductive age. All trout stocking in the study section of Wiscoy Creek was removed after 1971. With the removal of stocking, fishing pressure dropped to under 500 hrs/ac by 1974.

From 1978-1981, there was an increase in the number of wild brown trout in the control section, while the numbers in the special regulation section remained steady. There was also a large increase in populations of non-trout (primarily white sucker, *Catostomus commersoni*) in the control section. Pomeroy (1979) speculated that prior to 1978, the use of copper sulfate in several large ponds adjacent to the stream but upstream of the control sampling section had a detrimental effect on insect and fish populations. In addition, the amount of Wiscoy Creek water diverted through these ponds decreased substantially after 1980, likely improving water temperatures (Evans 1990).

Beginning in 1982 and continuing to the present, the Wyoming County section of Wiscoy Creek (including the control section) was regulated with a 10 inch minimum size limit, 3 trout/day creel limit, with no lure or bait restrictions. From 1982 to 1994, the one-mile long special regulation section retained the same size and creel limits with only artificial lures allowed.

The 1988 electrofishing survey showed large changes in the Wiscoy Creek wild brown trout population. Estimated numbers of brown trout in the special regulation section had increased to 1,570/mi and the population in the control section increased to 1,680/mi (Evans 1990). These increases were confirmed in 1991, with an estimated 1,601 brown trout/mi in the special regulation section and 1,515/mi in the control section (Evans 1992). It is unlikely that these increases could be explained by regulation changes. In1980, both sections had five trout/day creel limits, with the special regulation section having a 10 inch size limit and the control section a 9 inch size limit. By 1988, both sections had 10 inch size limits and 3 trout/day creel limits. Modest differences in fishing regulations between 1981 and 1988 would not be expected to account for such a substantial increase in trout numbers.

More likely explanations for increased wild trout abundance include improved water quality, decreased water temperatures, decreases in fishing pressure, and voluntary decreases in angler harvest. While we have no direct evidence for water quality and temperature improvements on Wiscoy Creek during this time, such improvements do correspond to increasing wild trout populations on many streams across western New York (NYS DEC file data). From the 1977 to the 1988 Statewide Angler Surveys, angler use on inland trout streams in New York dropped substantially (Connelly et al 1990, Kretser and Klatt 1981), perhaps associated with increased use of the Great Lakes salmonid fishery that is readily accessible to western New York anglers. The 1997 angler contact survey showed that angler use had dropped to almost half of what it had been in 1974 and anglers reported voluntarily releasing 72% of the legal size fish they caught (Evans and Cornett 1998). Similar high release rates have been noted for other western New York waters (Evans 1994, Evans 1998a, Evans 1998b).

Sampling in 1997 indicated that there were over 40% fewer trout in the control and former special regulation sections of Wiscoy Creek than in 1988 or 1991. Severe flooding in January 1996 eliminated much of the 1996-year class of brown trout that would have contributed to the yearling catch in 1997. Yearlings normally make up 40-50% of the Wiscoy Creek trout population. By the 2001 sampling, estimated trout numbers had rebounded to nearly those found in 1991 (Evans and Cornett 2002).

The brown trout population in the catch and release section of Wiscoy Creek has shown a steady increase from 1992-2001 surveys. Some of this increase occurred before the catch and release regulation went into effect in late 1994, perhaps as a result of more favorable water temperatures and increased trout reproduction in this section of Wiscoy Creek. The continued increase has occurred mainly through the stockpiling of age 1-3 fish. There has been an increase from 6 trout/mi to 27 trout/mi for the estimated number of fish >14 inch, but large fish are still rare in the catch and release section. This may be a function of high intraspecific competition for food and habitat, short life expectancy, out-migration of larger fish, or a combination of these causes (Evans and Cornett 2002). Barnhart and Engstrom-Heg (1984) and Thorn and Anderson (1993) reported similar age and size structures for wild brown trout in other small streams with highly restrictive harvest regulations. The trout population in the catch and release section (lying nearer the headwaters) was not affected by the January 1996 flooding, thus 1997 population estimates did not show the decreases found in the lower sections.

Conclusion

Wiscoy Creek's trout fishery has developed from one relying almost exclusively on hatchery trout to today's fishery based solely on wild brown trout. From 1940 to 1968, the increased abundance of wild trout was related to improvements in riparian habitat associated with changes in livestock pasturing and land use practices. From 1968 through the late 1970's, the implementation of restrictive angling regulations and the cessation of stocking hatchery trout were likely causes for improvements. Improvements in water quality, reductions in angler pressure, the voluntary release of legal size trout by anglers, and the implementation of the catch and release section have been associated with additional increases in wild trout abundance observed during the latter portion of this study.

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A Case History in Fishing Regulations in Great Smoky Mountains National Park: 1934-2004

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ABSTRACT—Since the establishment of Great Smoky Mountains National Park (GRSM) in 1934, managers have used nearly every regulation in the toolbox to manage salmonids. This study determined if regulations affected the age/size structure, growth, and population dynamics of wild rainbow trout populations within GRSM. The number of legal trout per km of stream ranged from 215-885 throughout the 70 year study period regardless of regulation. There were no statistical differences in trout relative stock densities (RSD) on Little River between the 1930's, 1950's, 1980's and 1990's, despite liberal regulations prior to 1960. Rainbow trout mean length at age data indicate no differences among populations for age-1 to age-4 trout. There was no statistical difference between age-1 to age-4 trout collected in 1945 and 1993. Water quality data indicate GRSM streams are naturally acidic and infertile which results in populations that exhibit fast growth and high annual mortality rates. Regulations provided no discernable effect on wild rainbow trout populations in GRSM. Most regulations were put in place for social reasons and were never evaluated over long-term periods (>5 years). Abiotic events (i.e. droughts and floods) have a much greater effect on salmonid abundance in GRSM than regulations or fishing pressure.

Introduction

Fishing has been a traditional recreational activity of the National Park Service system since congressional authorization of Yellowstone National Park in 1872 (Panek 1994). Every year, over 50 million Americans enjoy fishing in National Parks, one of the few consumptive resource activities available to National Park visitors (Recreational Fishery Resource Plan 1997). Fishing for salmonids is an ever popular and growing recreational activity in the United States, however, pristine coldwater habitat continues to diminish putting additional pressure on finite resources (Epifanio 2000).

Traditionally, fishing regulations for coldwater streams were generally used to protect or enhance a fishery for the benefit of various users (Noble and Jones 1999). However, National Park Service policies mandate that fishing regulations are geared towards the "protection" of native species *first* and the "enhancement" of fisheries second. Emphasis is placed on naturally reproducing populations before any resource allocations are made for angling (Jones 1984).

Fishing regulations typically play a greater role in the management of coldwater fisheries due to the low water fertility and slow growth of fishes in these unproductive areas, such as in Great Smoky Mountains National Park (GRSM) (Noble and Jones 1999). Few comparative studies of the effects of various fishing regulations as management techniques for salmonid populations exist (Power and Power 1996). Between 1934 and today, fishery managers in GRSM used a wide variety of regulations to manage salmonids. Formal reviews of these regulation changes and their effectiveness, in many cases, were never attempted. The objective of this study was to determine if various fishing regulations were effective in enhancing or influencing salmonid age structure, size structure, growth, and population dynamics over 70 years (1934-2004). Consistent population data for native brook trout and non-native brown trout were lacking throughout the study period. Only rainbow trout data were consistently available throughout the study period, therefore, we only analyzed rainbow trout data in this study.

Methods

A time series plot was used to evaluate rainbow trout abundance from 1938 to 2003 on similar sections of East Prong Little River. For each year, mean number of rainbow trout >178mm (7 inches) per stream km were reported. No standard deviations or raw data were available from 1938 to 1956, therefore only means were reported for all data. The data were divided into two groups (pre-1960 and post-1960) and analysis of variance (ANOVA) was used to test for differences in the mean number of legal rainbow trout per km between groups. The year 1960 was used as a break point because regulations prior to 1960 were rather liberal compared to those after 1960. Significant differences were noted at $P<0.05$ in all tests.

Rainbow trout size structures were compared using relative stock density (RSD) among several length categories. Traditional length categories assigned to rainbow trout (Anderson and Neumann 1996) could not be used due to the relatively small total lengths of wild rainbow trout in GRSM (*i.e.* ~80% of population <250mm or traditional “stock” size). Therefore, length categories were assigned with stock size equaling all rainbow trout >150mm. Relative stock densities (RSD’s) were then calculated for subsequent 25.4mm size classes from 178mm (current legal size) through 381mm. RSD values were compared in East Prong Little River between samples collected in the 1930’s, 1940’s, 1950’s, 1980’s and 1990’s time periods. The 1930’s, 1940’s, and 1950’s data were collected from intensive annual creel surveys on Little River during each period. In each period, the mean of two years of data (one year in 1940) were used to represent the period. RSD values were also compared between the 1985 and 1999 regulation periods on Abrams Creek. In each comparison, current data (i.e. 1990’s or 1999) were assigned as expected values and were compared to similar historic RSD values. Chi-square analysis was used to test for significant differences between historic and current RSD values.

Rainbow trout age structures were generated using scales samples collected from East Prong Little River in 1945 and 1993. Representative samples of the population were collected in 1945 using cresol while the 1993 data was collected using backpack electrofishing gear. Age structure distributions were compared using Chi-square analysis using the 1993 data as expected values.

Mean total lengths at capture (TL_c) were generated for rainbow trout collected in 1942, 1945, and 1995 in East Prong Little River. Scales were used to age rainbow trout for each year. Because only mean TL_c was reported for 1942 and 1945 (no raw data), no statistical comparisons could be calculated among mean TL_c for the three time periods. Mean TL_c and standard error bars are reported for 1995 data to indicate the relationship of the 1995 data to the 1942 and 1945 data.

Rainbow trout instantaneous mortality rates (Z) and total annual mortality rates (*A*) were calculated using catch curves (Van Den Avyle and Hayward 1999). Age groups with less than five fish were excluded from the analysis.

Rainbow trout total annual mortality rates from age-2 to age-4 were compared between 1957 and 1994 on Abrams Creek. Rainbow trout total annual mortality rates from age-1 to age-3 were also compared among Fish Camp Prong (1945), Little River (1996), and Sams Creek (1998). While Fish Camp Prong and Little River have always been open to fishing under given regulations of the time, Sams Creek has been closed to fishing for 28 years.

Visual implant (VI) tags were placed in all adult rainbow trout collected biannually (May &October) in standardized annual monitoring sites on East Prong Little River from 1991 to 1996. Sampling was conducted in roughly the same two months during the six year period. Scales were collected from all previously marked rainbow trout to enumerate age and record changes in total length (mm) and weight (g).

Results

The evaluation of the effects of various fishing regulations on GRSM salmonid populations was difficult for two reasons. Although numerous publications and internal summary reports are available throughout the study period (King 1942; Holloway 1945; King and Currier 1950; Lennon 1953; Lennon 1954; Lennon and Parker 1956; Lennon and Parker 1960), historical datasets were rarely published or archived making data comparisons over time very difficult. In addition, there was little consistency among the types of data collected, areas sampled, or sampling methodologies. A second reason the evaluation of effects was difficult was that the effectiveness of regulation changes was traditionally based upon short-term evaluations (i.e. <2 years).

Despite a wide variety of regulations and heavy stocking from 1934 to today, the number of legal rainbow trout per km of Little River from 1938 to 2003 remained consistent (215-885 per km) and variation appears similar throughout the study period (Figure 1). In addition, there was no significant difference

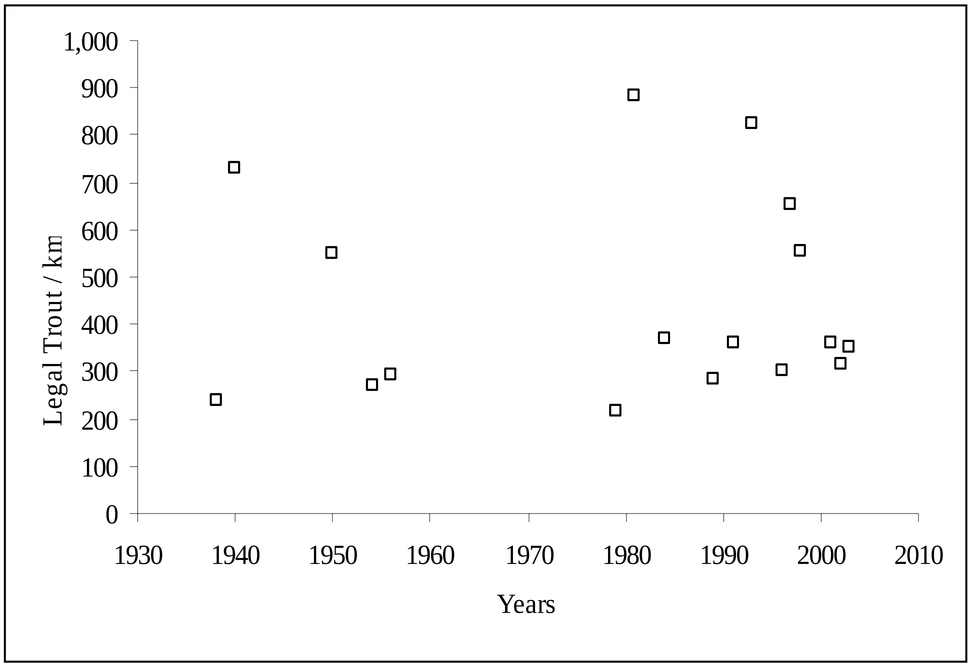

Figure 1. Time series plot of the mean number of legal rainbow trout (>178mm) per km in East Prong Little River from 1938 to 2003. No standard deviations were reported from 1938 to 1956, therefore only means were reported for all data.

between the number of legal rainbow trout among pre-1960 and post-1960 data (df=15, p=0.73), despite the stocking of fingerlings and catchables coupled with rather liberal regulations in the pre-1960 period.

RSD values in East Prong Little River in the 1930's, 1940's, 1950's, and 1980's indicate no significant difference between the 1930's (df=3, F=3.57), 1950's (df=3, F=2.10), 1980's (df=3, F=0.73) and the 1990's (Figure 2). There was a significant difference (df=3, F=11.92) between the RSD values for East Prong Little River in the 1940's and 1990's samples. RSD value comparisons between 1985 and 1999 on Abrams Creek indicate RSD values were significantly greater in 1999 than 1985 (df=5, F=20.87, p>0.05).

Rainbow trout age structure was compared between representative samples collected parkwide in 1945 (N=928) and in 1993 (N=107). Five age classes were represented in 1945 and four in 1993 (including age-0), with both datasets were dominated by age-1 fish (60 and 69% respectively). There were no significant differences (df=3, F=4.04) in the age structure distributions for age-1 to age-4 rainbow trout collected in 1945 and 1993.

Because only mean TL_c was reported for 1942 and 1945 (no raw data), no statistical comparisons could be conducted among mean TL_c for the three time periods. However, visual comparisons of the 1995 TL_c standard error bars (SE) indicate the bars overlap the means for age-0 and age-3 fish in 1942 and 1945 suggesting no major differences in TL_c among the three time periods (Figure 3). In addition, the mean TL_c for age-1 and age-2 fish in 1942 and 1945 are extremely close the SE bars for 1995 indicating these growth patterns are probably also similar.

Total annual mortality rates (A) for Abrams Creek were nearly identical between 1957 (58%) and 1994 (57%) for age-2 to age-4 rainbow trout. Instantaneous mortality rates (Z) ranged from 0.85-0.89. Total annual mortality

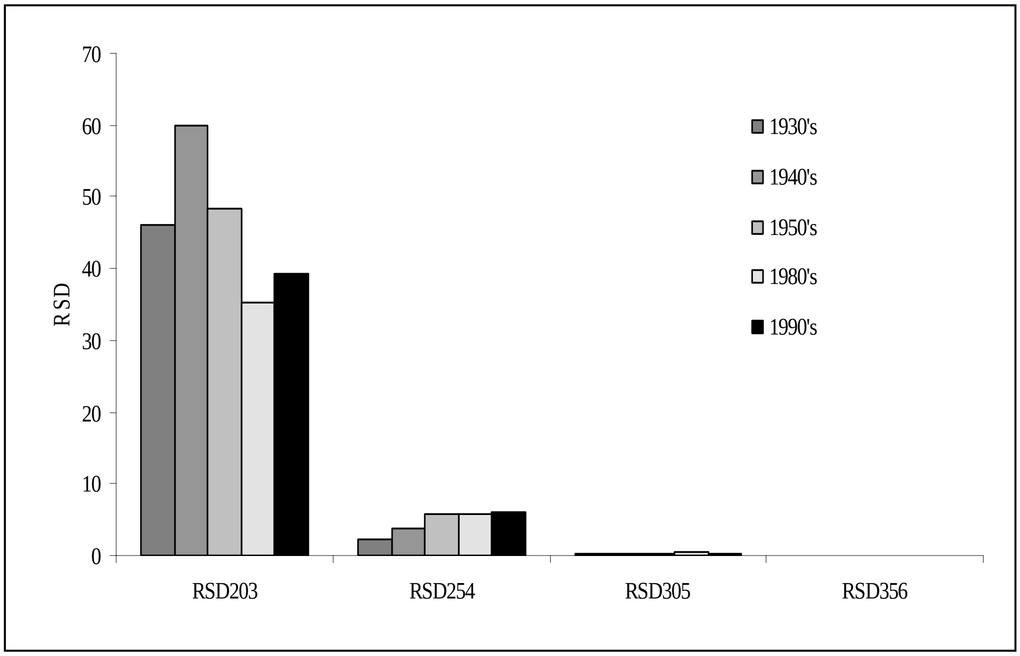

Figure 2. Relative stock densities (RSD) of rainbow trout collected in East Prong Little River in the 1930s, 1940s, 1950s, and 1980s compared to the same sites in the 1990's. The 1930s, 1940s, and 1950s data were collected using angler creel surveys whereas the 1980s and 1990s data were collected using backpack electrofishing techniques.

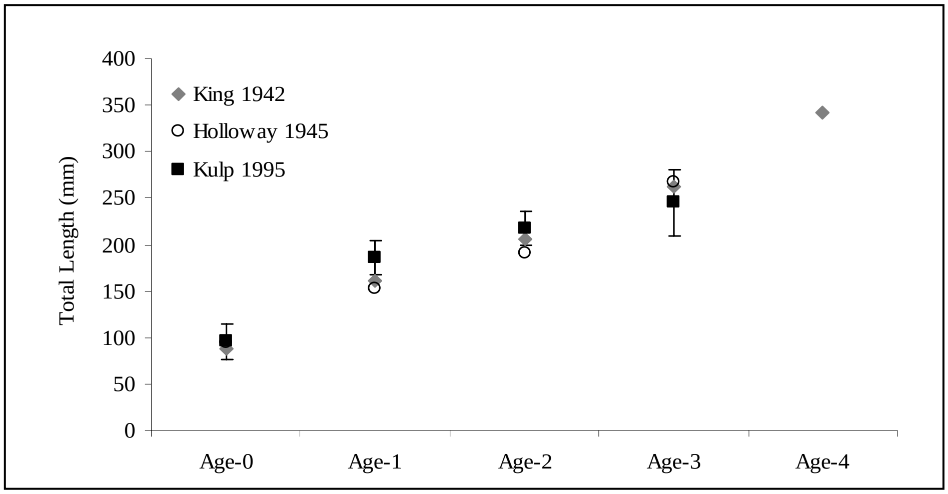

Figure 3. Mean total length at capture for rainbow trout collected in East Prong Little River during fall large stream samples in 1942, 1945, and 1995. *Note*: Raw data was not available for the 1942 and 1945 data, therefore only means without standard deviations are reported. The 1995 data include the mean total length at capture (black box) and standard error (bars).

rates of age-1 to age-3 rainbow trout were also compared among three streams sampled in 1945 (Fish Camp Prong), 1996 (Little River), and 1998 (Sams Creek).

Total annual mortality rates (A) among the streams ranged from 56-80% and Z ranged from 0.82-1.65. Fish Camp Prong (178mm size limit, 10 fish creel limit) and Little River (178mm size limit, 5 fish creel limit) were open to fishing under similar regulations during each period, although anglers were allowed to keep *injured* fish in 1945. Sams Creek had the highest A (80%) although it has been closed to fishing for 30 years.

Discussion

After reviewing the data throughout the 70 year regulation period, we could detect no changes in population dynamics that could be attributed to fishing regulations. A common problem among previous studies in GRSM and elsewhere was that adequate (*i.e*. 3-6 years) follow-up evaluations seldom occurred, making it difficult to evaluate the effectiveness of regulation changes.

Long-term data sets are difficult for many agencies to maintain, but are essential in order to evaluate the effectiveness of regulation changes. In the case of GRSM, a 3 to 6 year evaluation period would allow managers to evaluate the regulation change over at least one to two full generations. In short-lived salmonid populations such as in GRSM, it is even more important to evaluate a change over several generations in order to delineate regulation effects versus environmental effects such as major droughts and floods.

Stocking of fingerlings and/or catchable size trout appeared to augment the underlying wild trout populations in GRSM. Stocked trout met the demand of anglers who wanted fish that could be easily caught to fill their creel. In fact, 61-90% of catchable rainbow and brook trout were traditionally caught within three months of stocking (King and Currier 1950; Lennon 1953; Lennon 1954). The information presented by these authors strongly suggests that stocked trout buffered the wild trout from harvest and added no long-term benefit to the wild population.

Despite a diverse regulation history, heavy stocking rate (>1,000 fish/mile), and streams that historically represent some of the highest fishing pressure throughout the Park (Lennon 1953), the number of legal (>178mm) rainbow trout per km appears consistent and varied uniformly among study periods. Growth rates observed in the 1940's were nearly identical to those observed today, regardless of regulation type. The age structures of rainbow trout and the maximum age of rainbow trout (age-4) were statistically similar between two different regulation periods. Recent studies indicate the underestimation of rainbow trout age in the southeast when using scales (Hining *et al*. 2000; Cooper 2003), however these studies also recognize underestimations may only be one to three years and did not change total annual mortality or growth estimates. Total annual mortality rates were similar throughout the study period, regardless of regulation type. In fact, total annual mortality rates were actually higher in an unfished population (80%) than in heavily fished populations of 1945 (69%) and today (56-69%) (GRSM 1993). Total annual mortality rates (A) of age 1-4 rainbow trout in GRSM (56-80%) are similar to studies of Habera *et al.* (2001) (68%) and Cooper (2003) (34-89%) in surrounding Tennessee wild trout waters. Annual angling mortality rates (15%) in GRSM (GRSM 1993) comprise such a small proportion of the total annual mortality (56-80%), minimum size limits are of little value on a population scale (Noble and Jones 1999).

By adapting RSD's to GRSM populations, we were able to compare the contribution of various size groups to the whole population of "stock" size (>150mm) rainbow trout. Comparative data from East Prong Little River across regulation periods indicates the proportions of rainbow trout in four length categories are not significantly different from 1934 to today. Despite heavy fishing pressure, heavy stocking rates, and rather liberal regulations from 1936-1954, only the RSD values for East Prong Little River during the 1940 time period were significantly different than those of the 1990's. The higher proportion of rainbow trout >203mm in 1940 than in other periods may be explained by GRSM stocking records. These records indicate 11,132 fingerling and catchable size (>178mm) rainbow trout were stocked in Little River in 1940 versus 0-19,250 fingerlings annually in the 1930's (dependent on year) and <6,000 catchable size annually in the 1950's. The size composition of the 1940 stockings is unknown, but it is interesting to note that only the RSD_{203} category for this period appears to be different.

RSD values within Abrams Creek were significantly higher in 1999 (178mm size limit) than in 1985 (305mm size limit) suggesting regulations played little role in the ability to protect and recruit large rainbow trout in the population. Personal communications of one of the authors (S.E. Moore) with early Park descendants point out that a large majority (>80%) of the rainbow trout caught by anglers during the 1930's and 1940's ranged from 150-254mm with very few reaching sizes >305mm (<10%). These observations are supported by current data which indicate only 17% of rainbow trout reach 254mm and 3.2% reach 305mm. Additionally, size structure data collected in 1992 from Little River (open to fishing) and Sams Creek (closed to fishing since 1976) were nearly identical.

The productivity of southern Appalachian headwater streams is extremely low in comparison to wild trout streams in other parts of the world (Cada *et al.* 1987). The low productivity, subsequent naturally occurring food limitations, extremes in temperature and stream discharge, and high stream gradients inhibit rainbow and brook trout from attaining larger sizes in southern Appalachian headwater streams (Lennon 1967; Ensign *et al.* 1990; Borowa *et al*. 2001). In most areas, rainbow and brook trout simply run out of food resources to maintain metabolic demands, begin to lose weight, and die (Ensign *et al.* 1990, Cada *et al.* 1987). Ensign *et al.* (1990) determined that metabolic maintenance requirements of rainbow trout in GRSM typically drop below daily maintenance requirements and fish actually lose biomass over the June to September period. Visual implant (VI) tag data collected in GRSM support Ensign *et al.* (1990) and indicates annual rainbow trout net weight (g) change ranges from 17.71-28.47g/yr up to 178-203mm then steadily declined to a loss of 3.00g/yr in fish greater than 230mm. Whereas rainbow trout >178mm will grow 15-25mm and gain 15-32g from September to May, these same fish will only grow 1-16mm and *lose* 4-10g from May to September. The combination of high summer water temperatures (15-22^{o}C), higher metabolic rate, and food limitation create a critical period for salmonids in GRSM, especially those >203mm.

Borowa *et al*. (1995) found that supplemental feeding of a wild rainbow trout population resulted in numerous fish up to 406mm, whereas few fish >177mm existed before. Furthermore, Borowa *et al*. (1995) found that less than 1 year after feeding began, roughly 60% of the fish >100mm were over 176mm. In typical GRSM and east Tennessee wild rainbow trout populations, <25-40% of the entire population reaches 178mm (GRSM 1993; Habera *et al*. 2001). King (1938) and current GRSM (1993) data suggest that droughts, major spring floods, and food availability (Habera *et al*. 2003; Cooper 2003) play a much larger role in population abundance, growth, and annual mortality than any regulations employed throughout the history of GRSM (Thorn *et al.* 1997; Freeman *et al.* 1988; Grossman *et al.* 1998). King (1942) recognized droughts and floods play a major role in salmonid dynamics in GRSM, however data were not collected to support his hypothesis.

The southern Appalachian Mountains receive some of the highest loading of nitrate and sulfate due to episodic acidification of anywhere in North America (Robinson *et al*. 2001). To date, stream acidification impacts have been restricted to streams at elevations >875m. Episodic acidification has the potential to reduce the abundance, growth and reproductive potential of salmonids in small streams (Baker *et al*. 1996). Comparisons of data from Robinson *et al*. (2001) and Powers (1929) indicates that water quality has not significantly changed in lower elevation streams (<875m), such as those examined in this study, in the last 75 years. However, if current modeling trends continue as projected, all GRSM streams will be at or <6.0 in 32 years (Robinson *et al*. 2001) potentially increasing natural mortality and further reducing growth rates.

Based upon our review of the fishing regulation history of GRSM, the goal of most regulations was to produce higher densities and larger trout for the angler. The naturally acidic, high gradient, and food limited streams of GRSM produce short lived and relatively fast growing rainbow trout populations. Given these natural limitations, it is not difficult to understand why fishing regulations with these objectives failed to produce changes in rainbow trout population dynamics over the 70 year study period. If previous investigators had synthesized water quality and fish population data available at the time instead of using emotional and social views, they may have avoided implementing regulations that raised false hopes of anglers.

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An Analysis of Wild Trout Anglers in Virginia

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ABSTRACT—Virginia is blessed with over 2,300 miles of wild trout streams. Under Virginia's current licensing system, it is difficult to accurately determine how many anglers target wild trout. However, recent surveys indicate that the number of wild trout anglers could approach 60,000. Understanding Virginia's wild trout anglers and their impacts on the resource will be important components in making future management decisions. A survey protocol was developed to have volunteers conduct roving angler/creel surveys on selected wild trout streams. Members of Trout Unlimited (N=60) surveyed thirteen streams over a three-year period (2001-2003). The streams selected varied in angler access difficulty, land management responsibility, and fishing regulations. Three-hundred-forty-three anglers were interviewed during the study. We found that wild trout streams are a valuable economic resource, generating an average trip expenditure of $34.00. Wild trout anglers in Virginia are a dedicated group that averaged eighteen wild trout outings a year. However, angling pressure on individual streams was light (mean=283 angler hours/km). Angling pressure was generally higher on streams managed under special regulations ($P<0.05$). Wild trout anglers experienced excellent catch rates (mean=1.67 fish/hr), practiced catch-and-release (>99%), and were satisfied with their angling experience (90%). Angler creel surveys are often time consuming and costly. With increasing natural resource agency budget shortfalls, this project demonstrated that valid data can be obtained utilizing volunteers at minimal expense.

Introduction

There are two critical components in managing a fishery: understanding the biological functions of the fish population and determining the interactions of anglers with that fish population (Matlock 1991). Virginia contains over 2,300 miles of wild trout streams. The biology of these wild trout fisheries is well understood (Mohn and Bugas 1980). However, there is little information available regarding fishing pressure on wild trout fisheries or wild trout anglers in Virginia. Currently, most wild trout populations in Virginia are managed by factors other than angling pressure. Understanding Virginia's wild trout anglers and their impacts on wild trout resources will become more important in making future management decisions. Under Virginia's current licensing system, it is difficult to accurately determine how many anglers target wild trout. The state of Virginia does not require a special trout license or trout "stamp" to fish for wild trout. Anglers are only required to possess a trout license to fish in streams stocked with hatchery-reared fish. The state does stock some streams that contain wild trout populations , but the vast majority of wild trout streams do not receive hatchery fish. Stream creel surveys have traditionally been conducted by seasonal employees of the Virginia Department of Game and Inland fisheries (VDGIF) in the Commonwealth. With increasing budget reductions, an alternative method to acquire angler/creel data requiring no funding was investigated.

Methods

We visited several Trout Unlimited chapters prior to the start of the project. During this visit the goals and objectives of the study were discussed and survey protocols were explained. A letter explaining the project procedures and survey schedule were also given to volunteers that planned to participate. As an incentive to increase volunteer participation, creel clerks were encouraged to fish while conducting the survey. The author was in contact with a volunteer coordinator for each stream throughout the survey period. VDGIF personnel also assisted in conducting surveys. A random stratified roving creel design was chosen (Malvestudo 1996).

It was decided that a minimum of six survey days per month were required to get meaningful data. Based on prior knowledge it was determined that more angling pressure would occur during weekend days than during the week. Therefore, four weekend days and two weekdays were randomly chosen each month. Equal probability was used for selecting individual weekdays. The survey period for each year was 01 March through 30 June. This was considered to be the time period when the majority of angling pressure would occur on the study streams. Each survey day was stratified into either a six-hour morning or afternoon period. The afternoon time period was shifted as daylight length increased to cover the evening hours. The thirteen streams chosen for the study were all located in western Virginia (Figure 1).

One objective was to select study streams with different degrees of accessibility, public land management, and fishing regulations. Surveying an equal number of streams with different fishing regulations, angler access, and land ownership was not achieved. Nine of the thirteen streams were managed under some form of special regulation. These special regulations involved either 9-inch minimum size limits or catch and release, and gear restrictions. The remaining four streams were managed under statewide regulations for trout (7-inch minimum size, no gear restrictions). Four streams were located within the Shenandoah National Park (SNP). Nine of the study streams were located within land managed by the United States Forest Service. Two of the streams were located within designated "Wilderness Areas" on the National Forest. Angler accessibility also varied among the study streams. Two streams had easy roadside

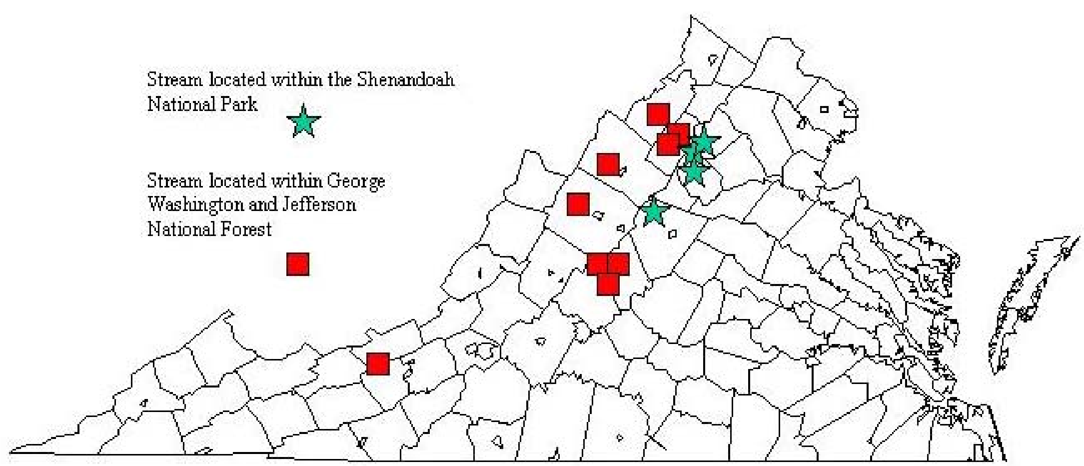

Figure 1. Map of Virginia with locations of streams surveyed during wild trout angler/creel surveys 2001-2003.

access while the remaining streams surveyed were accessible only by foot trails. Study reaches were all “headwater” first through third order streams. Characteristics of the study streams are summarized in Table 1.

All the study streams contained excellent wild brook trout populations, and one stream also contained a wild rainbow trout fishery. To estimate angling pressure, the creel clerk was instructed to travel/fish through the study reach during the first half of the survey period (3 hr), and to make a progressive total angler count. Then the clerk was instructed to travel/fish back through the study reach the second half of the survey period (3 hr) and to make a second progressive total angler count. To determine trip length all anglers were asked how long they had been fishing and how long they planned to fish if it was not a completed trip. In determining catch and harvest rates, anglers were asked how many fish they had caught and released or harvested. They were also asked to estimate the size (inches) of each trout angled. To gather wild trout angler information, a series of questions were asked to all willing anglers encountered during the survey (Figure 2). All daily angler count forms and questionnaire forms were returned to biologists at the end of each month. Data analysis was performed by Steve Malvestudo (private consultant) and the authors.

Table 1. Stream characteristics and creel survey statistics from Virginia Wild Trout Angler/Creel Surveys conducted 01 March-30 June, 2001, 2002, and 2003.

Stream	Land Ownership[1]	Angler Access	Special Regulations[2]	Days Surveyed	Anglers Interviewed	Est. Angler Hours (SE)	Angler Hours per Kilometer
2001							
Jeremy's Run	NPS	Walk-in	Yes	24	32	776 (32)	119
L. Stony Creek (Craig Co.)	USFS	Walk-in	Yes	24	40	834 (24)	208
Rapidan River	NPS	Vehicle	Yes	20	99	10,215 (13)	1,517
Shoe Creek	USFS	Vehicle	No	21	8	181 (44)	120
St. Mary's River	USFS*	Walk-in	Yes	15	29	1,488 (26)	330
2002							
Gum Run	USFS	Walk-in	No	9	4	130 (61)	43
Madison Run	NPS	Walk-in	Yes	10	5	367 (49)	183
Cub Run	USFS	Vehicle	No	20	5	344 (78)	172
N.F. Buffalo R.	USFS	Walk-in	Yes	16	16	462 (40)	154
Pitt Spring Run	USFS	Vehicle	No	20	4	120 (63)	40
Rose River	NPS	Walk-in	Yes	12	44	2,542 (25)	508
2003							
L. Stony Creek (Shen. Co.)	USFS	Walk-in	Yes	25	13	267 (45)	59
Ramsey Draft	USFS*	Walk-in	Yes	12	3	663 (49)	189
Rose River	NPS	Walk-in	Yes	20	41	1,577 (29)	315
Mean						1,426	283
Total					343		

[1] NPS refers to National Park Service (Shenandoah National Park); USFS refers to United States Forest Service (George Washington or Jefferson National Forest)

[2] Special regulations = catch-n-release or minimum length limit with gear restriction.

* denotes Wilderness Area

Figure 2. Volunteer creel clerk interviewing a wild trout angler.

Results

Thirteen streams were surveyed over a three-year period (2001-2003). One stream (Rose River) was surveyed in both 2001 and 2002. Sixty Trout Unlimited members representing five Virginia chapters helped to conduct the surveys. A total of three-hundred-forty-three anglers were interviewed during the project. The majority of interviews came from five streams. Each stream was scheduled to be surveyed 24 days during the study. However, volunteer participation varied and survey effort was not equal among all streams. Some streams were only surveyed 40% of the scheduled days. The mean number of days a stream was surveyed was 18 (Range 9-24).

Estimated fishing pressure ranged from 120-10,215 angler hrs/survey period, and averaged 1,426 angler hrs/survey period among all the streams. The mean relative standard error of total estimated angler hours for all streams was 51. The length of stream reaches surveyed ranged from 1.5 to 6.5km. Total estimated seasonal angling pressure on the study streams ranged from 40 to 1,571 hours/km. Angling pressure was roughly four times greater on streams managed with special regulations ($P<0.05$). Mean spatial angling pressure for special regulation streams and open regulation streams were 358 hrs/km and 94 hrs/km respectively. Streams located in the SNP received three and one half times the angling pressure than those streams located on National Forest land ($P<0.05$). Overall, there was no correlation between angler accessibility and fishing pressure. It should be mentioned that the Rapidan River in SNP received almost eight times the angling pressure, as did all the other streams in the study. The Rapidan River is the only stream survey managed under a catch and release/single-hook-artificial-lure only regulation, and had the easiest angler access. The Rapidan's notoriety can be attributed to the presidential Camp Hoover being located along it's banks. It was also the first wild trout stream in Virginia to be managed with a special regulation.

Wild trout anglers experienced a mean catch rate of 1.67 fish/hr during the project. Catch rates ranged from 0.3 to 3.72 fish/hr. Almost every angler exclusively practiced catch and release (>99%), as only one angler interviewed harvested trout. Anglers were asked if they would harvest legal-size wild trout.

Eighty-seven percent of the anglers responded that they would not harvest a legal-size trout. We were curious if anglers only practiced catch and release because they were not catching fish of legal size. In the study streams a trout had to be either a minimum of 7” or 9” in total length (depending upon the stream) to be legally harvested. Using the estimated lengths of fish that anglers reported catching ,we found that 50% of the anglers caught fish of legal size. Anglers were asked how often they fished the study stream in a year. Wild trout anglers indicated that they made an average of 4.4 fishing trips a year on that particular stream. Days fished a year on individual streams ranged from 1.3 to 6.9. Anglers were also asked how many days a year they fished wild trout streams in Virginia. Wild trout anglers in Virginia are a dedicated group that averaged 18 wild trout outings a year. Anglers were asked to rate their fishing experience for that particular day on a scale of 1-5. Responses of 3, 4, or 5 were considered to be a “satisfactory” angling trip. It appears that wild trout anglers in Virginia are happy with the status of the wild trout fisheries in the commonwealth. Ninety percent of the anglers interviewed indicated that they were satisfied with their angling experience on that day. In determining what gear type wild trout anglers prefer, we found that 87% of the anglers interviewed used fly rods. Even though any single-hook artificial lure could be used on nine of the study streams, 90% of the anglers on these streams fished with artificial flies. Out of the four study streams open to bait fishing, only 40% of the anglers fishing these streams used live bait. None of the volunteer creel clerks encountered anyone fishing with illegal gear during the study.

Collecting demographic and economic information was also an important part of the project. We found that wild trout fisheries outside of SNP are local fisheries. The majority of anglers fishing these streams lived within the county in which the stream was located or an adjacent county. Streams within the SNP were fished by anglers from all over Virginia and many different states. A high proportion of anglers fishing streams within the SNP resided in the highly populated area of Northern Virginia and Washington D.C. In 2001 the Rapidan River within SNP was fished by anglers from ten different states. Anglers were asked how much money they spent on gasoline, food, lodging, equipment, and additional fees for that individual fishing trip. The average trip expenditure was $34.00. Traveling to the stream was the greatest expense to anglers, as most money was spent on gasoline.

As was stated earlier, a trout license is only required to fish for stocked trout in Virginia. In an attempt to determine the estimated number of wild trout anglers in Virginia, all anglers surveyed were asked if they also fished for stocked trout. A majority of anglers (60%) indicated that they also fished stocked trout streams. We also asked anglers if they possessed a valid trout license. Surprisingly, 93% of the wild trout anglers surveyed indicated that they had purchased a trout license. Regardless of their answer, creel clerks were asked to notify anglers that a trout license was not required to fish in un-stocked streams. For possible use in conducting future angler surveys, we asked anglers if they belonged to any fishing organizations or clubs. Slightly less than half (43%) of the anglers indicated that they belong to an angling organization. This was considerably higher than the 10% of trout license holders that said they belonged to a fishing organization in a recent Virginia trout angler survey (Mohn in-press). Trout Unlimited was the angling organization mentioned with the highest frequency.

Discussion

Most roving stream creel surveys are conducted by one or two trained creel clerks that are employed by the managing agency. We were unaware of any previous creel studies where multiple, untrained volunteers were used to survey an individual stream. It was not known what the participation level of volunteer creel clerks would be at the onset of the project. We felt that anglers would be reliable volunteer creel clerks. TU chapters were chosen as a source of volunteer creel clerks that could be easily mobilized. One incentive to get people to volunteer was that they could fish while surveying the stream. Unfortunately, survey effort varied greatly (Range 9-24 days) for individual streams during the study. The goal was to survey each stream 24 days (6 days/month) between 01 March and 30 June. Although sampling effort appeared minimal, estimated angler hours/km and corresponding standard errors were similar to other creel surveys conducted on wild trout streams in the eastern U.S. that utilized greater survey effort. Greene (1996) surveyd a Pennsylvania wild trout stream similar to the ones in this study 20 days a month for a three month period, and reported similar angling pressure. A North Carolina creel study revealed similar angling pressure estimates while surveying streams 20+ days/month for an eight month period (Borawa and Clemmons 2000). In comparison, a seven day/month creel survey was conducted on another Virginia wild trout stream producing similar angling pressure (Palmer 2000). The high angling pressure observed on the Rapidan River (1,571 angling hrs/km) can be explained by easy angler access and the stream's reputation. Palmer (2000) reported similar angling pressure (1,070 angler hrs/km) on Whitetop Laurel Creek in southwest Virginia. Whitetop Laurel Creek is also easily accessible with a great reputation. Rapidan River and Whitetop Laurel Creek are considered to be two of the best wild trout streams in Virginia (Ross 1999;Hart 2002). Catch rates in this study were similar to those reported from other wild trout stream creel surveys in the eastern U.S. (Borawa and Clemmons 2000; Palmer 2000; Greene 1996).

Estimating the number of wild trout anglers in Virginia is difficult under the current licensing system. A recent survey of trout license holders revealed that 55.5% of Virginia's trout anglers fish for wild trout (Mohn, in-press). In contrast, 93% of the wild trout anglers interviewed during this study purchased a trout license. Sixty percent of the anglers in this study did indicate they fished for stocked trout, in which case a trout license would be required. While it is not a requirement to fish for wild trout in Virginia, anglers that fish solely for wild trout might be purchasing a trout license to support the program or the agency. Roughly 100,000 trout licenses are sold annually in the commonwealth (VDGIF Licensing Dept. 2001). Based on what we learned from this study, the number of wild trout anglers in Virginia could approach 60,000.

The economic value of fisheries is becoming increasingly more important in making management decisions (Knuth and McMullin 1996). The average daily trip expenditure in this study ($34.00) was similar to that of the average daily trip expenditure in Virginia ($30.00)(USFWS 2001). Wild trout fisheries appear to be just as economically important as more "high-profile" fisheries in Virginia. Rundle (2000) reported a mean trip expenditure of $18.85 for Smith Mountain Lake, one of Virginia's most popular reservoirs. Anglers spent between $21-$38 a trip in 1999-2001 while fishing Briery Creek Lake, Virginia's "trophy" largemouth bass fishery (D. Michaelson pers. Comm.).

In this study streams managed with special regulations received greater angling pressure than streams under general statewide regulations. Many of the best wild trout streams in Virginia are currently managed with special regulations. There are no historical records of what fishing pressure was like on these streams prior to being managed with special regulations. Other fisheries managers have reported higher angling pressure on wild trout streams managed with special regulations (Greene and Weber 1996; Todd et al. 1999).

With increasing natural resource agency budget shortfalls, we demonstrated that reliable creel and angler survey data can be obtained by utilizing volunteers at minimal expense.

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McGee Lake, Wisconsin: 35 Years of Trout Management—Past Successes and Future Challenges

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ABSTRACT—McGee Lake is a 9.2 ha spring pond that has been intensively managed as a trout fishery for the last 35 years following state purchase in 1968. Initial fisheries surveys in 1969 revealed a natural reproducing *Salvelinus fontinalis* (brook trout) population with great potential. Unfortunately, there were also warmwater fish species present competing with the trout for food and space. The lake was chemically renovated in 1974, restocked with brook trout in 1975, and opened to fishing in 1976. The first several years provided great fishing with brook trout up to 584 mm harvested under liberal size and bag limits. The lake went through two regulation changes in the 1980's to try and build up numbers of larger fish and instill more of a catch and release ethic among anglers. Creel and fish population studies done in the 1980's showed that these regulation changes were not successful, although the lake still provided above average fishing for trout up to 381 mm. In the mid 1990's, *Micropterus salmoides* (largemouth bass) were illegally introduced to the lake and numbers and natural recruitment of brook trout vanished as the largemouth bass population quickly became established. We are now at a crossroads of either continuing to manage the lake for trout, realizing that illegal introductions of fish species that are competitors with and predators of trout may continue to happen, or switching gears and managing for warmwater fish species or as a combination warmwater/coldwater fishery. Several potential options will be discussed as well as a simple cost-benefit analysis supporting complete renovation and restocking with brook trout.

Background Information

McGee Lake, a 9.2 ha spring pond, has been intensively managed for trout since state purchase of the land surrounding the pond in 1968. McGee Lake lies in south central Langlade County WI, in the northeast part of the state. This region is home to one of the largest known concentrations of natural spring ponds. In Langlade County alone there are approximately 250 spring ponds ranging in size from less than 0.1 to 21.4 ha (Steuck et al. 1977). Most (64%) are less than 0.4 ha in size and McGee Lake is one of the four largest in the county. Spring ponds are spring-fed lakes that rarely have permanently flowing inlets, but always have substantial outlet creeks due to the influx of large amounts of spring water. Spring ponds are usually the headwaters, or in the upper watersheds of our native *Salvelinus fontinalis* (brook trout) streams. Rarely do spring pond outlet creeks in this region flow to warmwater streams. Spring ponds are highly productive systems when compared to other waters in this part of the state. Table 1 shows the chemical characteristics of McGee Lake.

Table 1. Chemical characteristics of McGee Lake based on a surface water sample taken on April 10, 1981.

Parameter	Value
pH	8.1
Total Alkalinity (mg/l as $CaCO_3$)	174
Specific Conductance (umhos/cm at 25°C)	340
Nitrates (mg/l)	0.07
Phosphates (mg/l)	0.02
Ammonia (mg/l)	0.03
Chlorides (mg/l)	2
Calcium (mg/l)	41
Magnesium (mg/l)	20
Potassium (mg/l)	2
Sodium (mg/l)	2
Sulfates (mg/l)	9
Iron (mg/l)	0.1
Turbidity	0.35

Table 2. Stocking history at McGee Lake 1938-2003. Numbers and species stocked by year(s).

1938[1]	1939-1953	1954-1974	1975-2003
Warmwater Species	**Trout**	**No Stocking[2]**	**Trout**
18,000 *Perca flavescens* (Yellow Perch)	77,425 Oncorhynchus mykiss (Rainbow Trout)		78,300 *Salvelinus fontinalis* (Brook Trout)
10,000 *Lepomis gibbosus* (Pumpkinseed)	39,350 *Salmo trutta* (Brown Trout)		25,700 Oncorhynchus mykiss (Rainbow Trout)
3,000 *Lepomis macrochirus* (Bluegill)	2,550 *Salvelinus fontinalis* (Brook Trout)		
3,000 *Ictalurus spp.* (Bullhead spp.)			

[1] *First recorded stocking in the files.*
[2] *No stocking recorded, presumably due to lack of public access.*

The first recorded fish management activity for McGee Lake was stocking done in 1938 (Table 2). The 1938 stockings of warmwater fish species were consistent with the state's practice of indiscriminate stocking done throughout the region at the time. From 1939-53 only trout were stocked. No stocking occurred from 1954-75. In 1968, the state purchased 22 ha of land, including all the shoreline around McGee Lake and 91 m along both sides of the outlet creek. The following spring and fall, the first recorded fish surveys of McGee Lake were completed. In addition to the presence of warmwater fish species, these surveys revealed a self-sustaining brook trout population with great potential; trout up to 417 mm were surveyed (Table 3). On July 25, 1969, a warm summer day with an air temperature of 26°C, a temperature and oxygen profile of McGee Lake was done. It was discovered that there was at least 6 ppm oxygen down to a depth of 6.7 m and temperature of 11°C. There was a 4-5 m band of cold, well-oxygenated water for trout to live in. It was decided to manage the lake as a trout fishery and plans to chemically renovate the lake began.

In October 1974, McGee Lake was simultaneously treated with a 3 ppm concentration of rotenone and a 10 ppb concentration of antimycin. The lake stayed toxic to fish for several months under the ice and it was believed that a total kill of all fish was attained. In spring and early summer 1975, the lake was restocked with 3,700 yearling brook trout (229 mm), 300 fingerling brook trout (76 mm), and 40 adult brook trout (254-381 mm).

Table 3. Initial fish surveys done at McGee Lake in 1969. Species, numbers, and sizes collected by survey period.

May Boom Electrofishing Survey	September Gillnetting Survey
Salvelinus fontinalis (Brook Trout) 3: 137-185 mm	*Salvelinus fontinalis* (Brook Trout) 19: 203-417 mm
Perca flavescens (Yellow Perch) Thousands: 51-229 mm	*Perca flavescens* (Yellow Perch) 87: 152-279 mm
Catostomus commersoni (White Sucker) Thousands: 76-432 mm	Catostomus commersoni (White Sucker) 166: 152-457 mm
Notemigonus crysoleucas (Golden Shiner) Thousands: 51-178 mm	Notemigonus crysoleucas (Golden Shiner) 18: 127-178 mm
Lepomis gibbosus (Pumpkinseed) 7: 127-178 mm	*Lepomis gibbosus* (Pumpkinseed) 1: 188 mm
Lepomis cyanellus (Green Sunfish) 6: 102-127 mm	Lepomis cyanellus (Green Sunfish) 7: 102-203 mm
Ictalurus melas. (Black Bullhead) 4: 178-203 mm	
Cottus spp. (Sculpin spp.) 1: 122 mm	
Phoxinus spp. (Dace spp.) Noted as common	
Notropis spp. (Shiners spp.) Noted as common	

Since 1975, only trout have been stocked (Table 2). From 1976-1988, and in 1990, 4,000 yearling brook trout (152-254 mm) were stocked. In 1989, 3,000 yearling *Oncorhynchus mykiss* (rainbow trout; 229-279 mm) were stocked. Two thousand yearling brook trout and 2,000 yearling rainbow trout were stocked from 1991-2000 with exceptions in 1996 (1,500 of each), 1997 (1,500 brook trout only), and 1998 (2,000 brook trout and 200 rainbow trout). In the years 2001-2003, 2,000-3,000 rainbow trout yearlings have been stocked.

The lake was closed to fishing in 1975. In May 1976, McGee Lake opened to fishing with the following regulations: first Saturday in May through November 15 season, 152 mm minimum length limit, 5 trout per day in May and 10 per day June through November, and no minnows allowed as bait. Fishing from 1976-1979 was phenomenal for a Wisconsin brook trout fishery with stringers of above average size fish being caught and harvested by anglers (Hunt 1979, 1984, 1989, Johnson 1976). Brook trout from 432-584 mm were not uncommon in anglers' creels. The fishery could not sustain the amount of fishing and harvest pressure it was receiving and still continue to consistently produce quality brook trout of these sizes. Therefore, the regulations were changed in 1980 and again in 1986. The objectives of these regulation changes were two-fold: to determine if they would provide adequate constraint on harvest to allow an abundant stock of large brook trout to remain throughout the fishing season, and to determine if they would attract a majority of anglers with more of a "catch and release" attitude instead of "catch and keep".

In 1980, fishing regulations at McGee Lake changed to the following: first Saturday in May through September 30 season, no minimum length limit, 2 trout per day, and no minnows allowed as bait. In 1986, the regulations remained the same except that only artificial lures were allowed. Hunt (1979, 1984, 1989) followed the fishery through creel and fish population surveys in 1977, 1980, 1981, 1982, 1986, and 1988 (Table 4). Evaluation of the 1980 regulation change determined that the two objectives were not being met, as average size of harvested brook trout did not increase significantly. Catch and keep fishing was more prevalent and did not allow McGee Lake to grow and sustain a large population of quality size brook trout. The regulation change to artificial lures only in 1986 was a next step approach to attempt to meet the objectives by attracting more non-local anglers that may have more of a catch and release attitude. This regulation also failed to meet the objectives as anglers continued to harvest more trout than they released. Throughout these studies and regulation changes it was noted that for a Wisconsin fishery, McGee Lake still provided above average fishing for quality size (> 203 mm) brook trout (Table 5; Hunt 1984, 1989; David A. Seibel, WDNR, unpublished data).

Trout regulations were changed once again in 1990 to a 305 mm minimum length limit but due to drought conditions and special regulations from 1989-1991, the new length limit didn't actually go into effect until the 1992 fishing season. In August and September 1989 and all of 1991, trout fishing rules were no harvest (catch and release only) and artificial lures only. Trout fishing was closed statewide in 1990. Figure 1 reveals that in 1994 brook trout appeared to be cropped off starting at about 292 mm, indicating that the new length limit regulation worked to protect brook trout up to this size.

Table 4. Numbers of brook trout captured, harvested, and released from McGee Lake based on a summary of angler creel surveys conducted in 1977, 1980, 1981, 1982, 1986, and 1988. Data is presented in hours per hectare, number per hour, number per hectare, and kilograms per hectare.

	Fishing Pressure	Brook Trout Catch		Brook Trout Harvest				Brook Trout Released		
Year	h/ha	No./h	No./ha	No./h	No./ha	kg/ha	Average Size (mm)	No./h	No./ha	% Released
1977	1129	0.58	655	0.51	581	-	-	0.07	84	11
1980	465	0.71	329	0.37	171	28	229	0.34	158	48
1981	507	0.67	339	0.45	230	39	241	0.22	111	32
1982	425	0.60	255	0.35	151	22	213	0.25	106	41
1986	151	1.10	166	0.57	86	13	249	0.53	79	48
1988	111	0.57	64	0.31	35	7	262	0.26	30	46
1980-82[1]	465	0.66	306	0.39	183	30	231	0.27	126	40
1986 & 88[2]	131	0.88	116	0.46	59	10	254	0.42	54	49

[1] *Average of years 1980, 1981, and 1982.*
[2] *Average of years 1986 and 1988.*

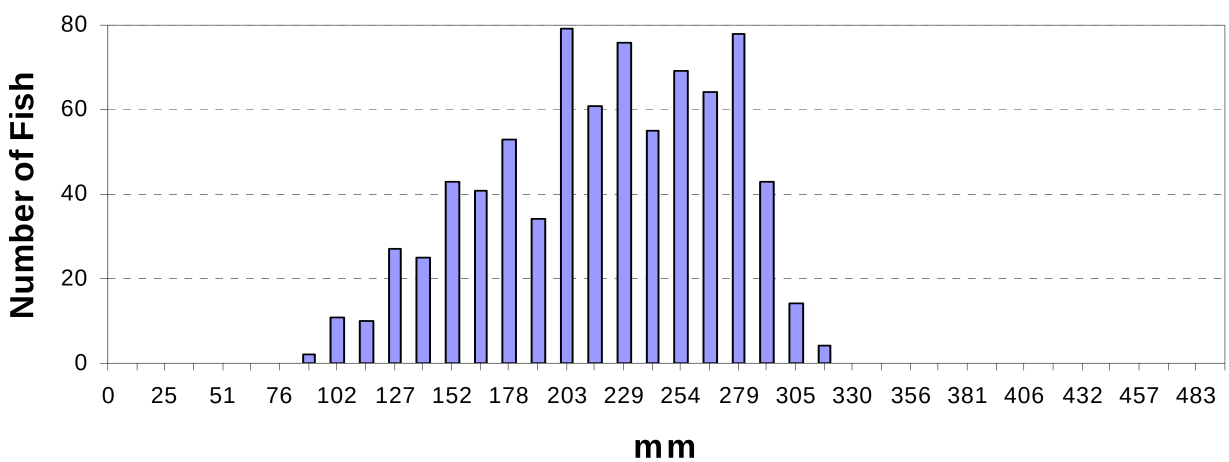

Figure 1. Length frequency histogram of brook trout surveyed with electrofishing in April 1994.

Table 5. Summary of brook trout population survey estimates at McGee Lake in 1980-82, 1985-88, 1994, and 2000-01. Data is presented in number ≥ 152 mm, number per hectare, and kilograms per hectare.

		Population Estimate						
		All Brook Trout			Wild Brook Trout			
Year	Month[1]	No. ≥ 152	No./h	kg/ha	No. ≥ 152	No./h	kg/ha	% Wild[2]
1980	April	292	32	12	292	32	12	-
	October	500	54	15	198	22	7	40
1981	April	371	40	18	145	16	8	39
	October	685	75	15	349	38	7	51
1982	April	464	51	15	240	26	7	52
	October	1358	148	29	568	62	12	42
1985	April	-	-	-	-	-	-	-
	October	1170	127	27	899	98	21	77
1986	April	574	62	10	518	56	8	86
	October	1439	157	30	573	62	10	35
1987	April	648	71	15	340	37	6	39
	October	754	82	13	377	41	6	44
1988	April	1283	140	24	832	91	13	55
	October	1596	174	26	1056	115	18	68
1994	April	1102	120	-	-	-	-	-
	October	-	-	-	-	-	-	-
2000	April	-	-	-	-	-	-	-
	October	95	10	-	95	10	-	-
2001	April	-	-	-	-	-	-	100
	October	198	22	-	198	22	-	100

[1] *Within a couple of weeks after the April population survey estimates, standing stocks of brook trout were bolstered by annual stockings of 4,000 (435/ha; 36 kg/ha) domestic yearling brook trout (1980-88; 1990) and 1,500-2,000 (163-218/ha; 10-23 kg/ha) domestic yearling brook trout (1991-1999). 2,000 domestic fingerling brook trout were stocked in fall 2000 (218/ha; 6kg/ha).*

[2] *Brook trout stocked prior to 1980 or of wild origin.*

Present Status of the Fishery

A 1994 brook trout population estimate revealed good natural reproduction with all size classes represented and above average size quality (Figure 1). It was decided to discontinue stocking brook trout to see if the population could sustain itself entirely through natural reproduction and recruitment. Then in the mid-1990's anglers started reporting catches of *Micropterus salmoides* (largemouth bass) in McGee Lake. In June 1999, an electrofishing survey found a well established largemouth bass population, likely the result of an illegal introduction. Subsequent electrofishing surveys from 2000-2002 further documented a significant bass population as well as a dramatic decrease in the brook trout population (Table 6). No brook trout less than 254 mm were present in the fishery, presumably due to predation by largemouth bass.

During the 1999-2002 electrofishing surveys, we removed all the largemouth bass we captured from McGee Lake. A total of 2,859 bass (311/ha) were removed from the lake during these surveys. No resurgence in the brook trout population was noted as the bass population rebounded quickly from these removals. In 2002, we enacted a fishing regulation (no size limit on bass) allowing harvest of all bass caught up to the daily bag limit of 5 fish. The trout season framework, and artificial lures only regulations still had to be followed. This was to encourage angler harvest of all bass captured to help reduce predation of, and competition with, brook trout. Although this regulation can only help, we are not optimistic that it will adequately keep bass numbers in check to have a positive response on the brook trout population.

Future Plans

We are now at a crossroads with fish management at McGee Lake. We would like to manage for the native species, i.e. brook trout, in its native habitat, preferably through a self-sustaining, natural-reproducing population. To do this we feel we must substantially reduce or eliminate the largemouth bass population in the lake. If the bass population is not controlled, they will continue to suppress the survival and recruitment of young brook trout and keep the total trout population numbers down. On the other hand, we could let the bass go unchecked and manage the lake solely as a bass fishery, or as a combination bass and stocked trout fishery. The angling public and local chapters of Trout Unlimited (TU) would prefer the lake be managed solely for quality size brook trout. They remember the great years of trout fishing following state acquisition, renovation, and management as a quality trout fishery, and desire to have this type of fishery back at McGee Lake.

Managing the lake solely for largemouth bass and panfish would be the least costly option, in terms of dollars spent. No stocking would have to occur and

Table 6. Electrofishing catch rates at McGee Lake in 1994 and 1999-2002. Data is presented in number per hour and number per hectare.

		Brook Trout		Largemouth Bass	
Year	Month[1]	No./h	No./h	No./h	No./ha
1994	April	282	31	0	0
1999	June	3	0.3	171	19
2000	October	15	2	223	24
2001	June	0	0	523	57
	October	18	2	96	10
2002	June	5	0.5	307	33

[1] *Within a couple of weeks after the April population survey estimates, standing stocks of brook trout were bolstered by annual stockings of 4,000 (435/ha; 36 kg/ha) domestic yearling brook trout (1980-88; 1990) and 1,500-2,000 (163-218/ha; 10-23 kg/ha) domestic yearling brook trout (1991-1999). 2,000 domestic fingerling brook trout were stocked in fall 2000 (218/ha; 6kg/ha).*

bass and panfish populations could be managed through regulations and periodic surveys. This type of management is the least expensive as annual costs would be less than $200/year and $4,500 over the next 25 years (2004 U.S. dollars).

Another option would be to manage the lake as a two-story fishery for largemouth bass and trout (rainbow and/or brook) in combination. We would have to annually stock larger trout at a higher expense to reduce predation on trout by bass. The current state budget situation is very tight and we have experienced complete cuts in stocked yearling trout fisheries in 2004 and 2005. Trying to get an even larger trout to stock into McGee Lake in these tough budget times is not a reality and would come at an even higher annual cost. Stocking 4,000 yearling trout averaging 279 mm would cost $6,000/year and at least $150,000 over the next 25 years.

We could continue to remove largemouth bass through the use of electrofishing. Studies have shown, as well as our experience with removing largemouth bass at McGee Lake, that partial removals are at best a very short-term solution and not a long-term fix. Despite our efforts to annually remove a large standing stock of bass from the lake, we did not see any positive response in the brook trout population. Young brook trout were not recruiting to the fishery. Removals would have to be done several times annually, to try to stay on top of the bass population. We could never get them all and it would quickly become a scheduling problem with our other fish management responsibilities. It would also be an expensive course of action as biannual largemouth bass electrofishing removal trips to McGee Lake would cost $1,500/year and $37,500 over 25 years.

Partial renovation is an option we have considered. We could treat the littoral areas with antimycin while the bass are spawning. The thought is, we could hit the bass while they are vulnerable and sustain limited trout mortality, as they should be out in deeper water at this time of year. We feel that this is not a very good option because it would likely not get enough largemouth bass to have a long-term, positive response on the brook trout population. At best, it would work for a limited time and would likely have to be repeated every couple of years. The costs of doing partial renovations every few years would be much more expensive than doing one complete renovation both in terms of money spent on chemical and on public relation efforts (information sessions, news releases, warnings, etc.)

A complete renovation seems to be the best long-term solution and most cost-effective option to manage the lake as a natural, self-sustaining brook trout fishery. We plan to use rotenone and/or antimycin to get a complete kill of all fish in the lake, just as in 1974. To help get that process started, we plan to use electrofishing to collect as many brook trout as possible from McGee Lake just prior to their spawning. These fish will be spawned, and they and their progeny kept at a local hatchery over winter. Renovation would again occur in October, prior to ice-cover, to maximize the length of toxicity and ensure as much of a total fish kill as possible under the ice. The trout held at the hatchery over winter will be restocked into McGee Lake when it detoxifies the following spring. Fishing will be closed for 2 years following renovation to give the adult fish 2 spawning cycles before being subject to fishing harvest. This time will also allow young fish to recruit to the fishery.

This winter (2004-05) we plan to write a project proposal to secure funding to renovate McGee Lake. We anticipate that the local TU chapters will be key partners with, and contributors to the project. Once the funding is secured, we will obtain the necessary permits, hold public informational meetings, and establish local support for the project. We plan to do a media blitz educating the public about the harmful effects of illegal fish introductions and the values of our native fisheries. Costs to carry out this renovation plan are around $25,000, or $1,000/year over 25 years (the first renovation lasted 25 years). Compared to the costs of hatching, rearing, and annually stocking 4,000 yearling trout over the last 30 years (1975-2003; $100,000 in 2004 U.S. dollars or $4,000/year), this plan appears to be a bargain.

Barring another illegal introduction of a species that significantly preys on brook trout or competes directly with them for food and space, we feel that this is the best, most economical solution (Table 7). We also have many supporters in the community watching out for the resource and educating people about illegal introductions. These watch dogs know that McGee Lake is a special resource and will do everything in their power to avoid an illegal stocking from happening again. We would also have the satisfaction of managing the lake for its native species as well as providing the fishery most anglers desire. It is hard to put a price on restoring a native, self-sustaining brook trout population.

Table 7. Estimated costs for future fish management options at McGee Lake. Costs are in 2004 U.S. dollars and include equipment, materials, maintenance, and salary/wage costs.

Management Option	Annual Cost ($)	25 Year Cost ($)	Prognosis
Manage for Largemouth Bass and Panfish (Non-Trout Management)	200	5,000	Mediocre bass and panfish fishery; One of over 1,000 bass and panfish lakes in the county
Stock Larger Trout (Two-Story Management)	6,000	150,000	Mediocre bass, panfish, and trout fishery; Will not reach trout fishery potential
Largemouth Bass Removals	1,500	37,500	Probably will not have the desired positive effect on the trout population; Possible to have limited short-term success but not a long-term solution
Partial Renovations (Largemouth Bass Removal)	4,000	100,000	Probably will not have the desired positive effect on the trout population; Possible to have limited short-term success but not a long-term solution
Complete Renovation (Start Over)	1,000	25,000	Long-term success barring another illegal fish introduction

Acknowledgments

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The Development and Evaluation of Conservative Trout Regulations in Southeast Alaska Based on Length at Maturity

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ABSTRACT—Populations of wild cutthroat and rainbow trout occur in streams and lakes throughout Southeast Alaska and are available to anglers year-round. In the late 1980s and early 1990s, biologists became increasingly concerned that these species were being overharvested. Emergency order closures of trout fisheries began in 1991 and continued during the following two years. In 1992 and 1993, an extensive literature review was completed and researchers from West Coast states and British Columbia were consulted on their trout management strategies. A public review process, including extensive public meetings and mail-out questionnaire, also contributed to a set of regulations adopted in 1994.

The cornerstone of the new regulations is a series of minimum size limits to protect 65% or—in areas with higher angling pressure—100% of trout from harvest until they have spawned at least once. Minimum size limits are only effective if hooking mortality is minimal; a ban on bait in fresh water was therefore considered an essential component of the new regulations. This paper reviews development of current regulations and our ongoing efforts to evaluate the effectiveness of minimum size limit regulations based on length at maturity research.

Introduction

Populations of wild cutthroat trout, rainbow trout, and steelhead occur in approximately 5,000 streams and lakes throughout Southeast Alaska and are available to anglers year-round. In the late 1980s and early 1990s biologists from the Alaska Department of Fish and Game (ADF&G), Sport Fish Division, became increasingly concerned that trout were being overharvested. These concerns stemmed from research findings as well as concerns expressed by fishing guides and the angling public. The only large-scale monitoring of freshwater angler effort, catch, and harvest was the Alaska Statewide Harvest Survey (SWHS). Trends reported in the SWHS showed a 72% increase in the number of days anglers fished in fresh water in Southeast Alaska between the 3-year averages of 1980–1982 and 1990–1992 (Mills 1983, 1993), whereas numbers of cutthroat trout harvested declined by 43% between the same time periods.

Because of these concerns, ADF&G used its “Emergency Order” (EO) authority to close several steelhead and cutthroat trout sport fisheries. In 1991, the Situk River was closed to steelhead retention (catch-and-release-only), and Turner Lake was closed to cutthroat trout retention. The following year, EO closures were issued for 24 steelhead systems and 3 cutthroat trout lakes (Turner, Wilson, and Reflection lakes). In 1993, the department closed 48 steelhead streams to retention of steelhead and retained the restrictions on the 3 cutthroat trout lakes. ADF&G staff and the public recognized a need to evaluate existing trout regulations and to develop new management strategies and regulations to protect trout resources in Southeast Alaska while providing maximum fishing opportunity.

Development of Wild Trout Regulations

The strategy adopted in 1992 to develop new trout regulations was to combine information collected from our trout research projects with the best management practices, then develop management options and present these options to the public for their input and preferences. Starting in fall 1992 and continuing through 1993, Southeast Alaska Sport Fish staff collected background information on cutthroat trout management through an extensive literature review and interviewed trout management biologists along the west coast of Canada and the U.S. to learn from their trout and steelhead management strategies. This information contributed significantly towards drafting ADF&G regulations.

ADF&G staff held two series of public meetings throughout Southeast Alaska. In the first, we shared our concerns about declining trout populations and sought input from citizens about their opinions of the status of trout stocks in their local areas. After all input was reviewed, angler preferences were incorporated into our "draft trout management options," and a second series of public meetings was held. Objectives at these meetings were to garner comments on our "draft trout management options" and to develop support for our preferred management options.

We decided to combine the regulations for cutthroat trout and rainbow trout because of difficulties anglers had in distinguishing between the two species. Moreover, because cutthroat trout are more vulnerable to angling pressure and habitat degradation (Behnke 1992), we felt that the biological principles used to protect cutthroat trout should also serve to adequately protect rainbow trout populations. We also discussed steelhead stock status and management options at our public meetings, and new steelhead regulations were developed concurrently with the proposed trout (cutthroat and rainbow trout) regulations.

Review of Literature and Trout Management Strategies

A review of the existing literature and contacts with other trout and steelhead managers revealed that cutthroat are the most easily caught of the trout species. Cutthroat trout are aggressive feeders and can be caught on a wide variety of gear types. They are particularly vulnerable to bait, and studies (Mongillo 1984, Wright 1992, Taylor and White 1992, Pauley and Thomas 1993) show that mortality rates for cutthroat caught and released using natural bait are as high as 48%, whereas mortalities from artificial gear (lures, flies, etc.) are lower than 5% (3,981 fish, in 16 total studies). Mortality rates for rainbow trout caught and released with bait were 28%, still much higher than artificial gear types (6.8%) (7,234 fish in 21 studies).

Hunt (1970) stated that size limits, if wisely applied, are the best regulations for preventing excessive angler harvest, because the size limit applies to every fish caught and thus can be related to specific biological parameters. Wright (1992) expanded upon Hunt in his review of the regulatory selection process for Washington State by discussing their regulation preference to protect a full age-class of female spawners. To maintain a trout population's reproductive potential, the minimum size limit should be set at a level that provides an opportunity for a full age-class of females to spawn at least once. However, because sport fishing regulations are based on length and not age-class, a minimum size limit was needed that would protect all female trout until they reached the size at which they were mature. Males typically mature when they are somewhat younger and smaller (Downs et al. 1997), thus any minimum size limit regulation designed to protect females should adequately protect males.

Length at maturity data for Alaska cutthroat trout stocks were limited to several years of data collected during the 1960s from sea-run fish in Petersburg Creek (ADF&G unpublished data). Other sources we used in establishing our minimum size limits came from landlocked populations in Mosquito Lake in the Queen Charlotte Islands, British Columbia (Leeuw 1987) and literature on trout populations in Washington and Oregon (Wright 1992). Information from these sources suggested that a 12-inch minimum size limit would allow approximately 85% of cutthroat trout in Southeast Alaska an opportunity to spawn at least once, and a 14-inch size limit would allow nearly all fish an opportunity to spawn at least one time.

One concern with size limits is the potential adverse effect of long-term size selectivity on heritable traits. ADF&G biologists believed that as long as “an adequate number” of fish above the minimum size limit are not harvested and allowed to spawn multiple times, then the genetic structure would not adversely change. At the time the regulations were developed, we knew of no sport fishery in Southeast Alaska that was so intense that every fish above the minimum legal size limit would be harvested. We also realized this might change and that ongoing monitoring would be necessary to maintain genetic integrity of our trout stocks.

Upon completing the literature review, ADF&G Sport Fish staff agreed that the two key management issues with trout (cutthroat and rainbow) were (1) establishing an appropriate minimum size limit and (2) restricting use of bait. A minimum size limit could be effective only if hooking mortality was low, and it would be meaningless without concurrent bait restrictions; a ban on bait in fresh water was an essential element of the new regulations. Further, because Southeast Alaska has thousands of remote lakes and streams, we can evaluate abundance in only a few; therefore, the new trout regulations needed to cover a wide range of situations and levels of angler pressure. Many of the trout populations were known to be small and unable to sustain much harvest. Thus, a minimum size limit that protected the majority of fish until they had the opportunity to spawn at least once made the most sense to ADF&G biologists.

A major concern was that the public might view new hatchery production as an option for increasing harvest. After reviewing the literature and history of trout hatcheries and associated problems, there was internal agreement that we did not want hatchery stocking of trout or steelhead in Southeast Alaska. The emphasis needed to be on implementing regulations that would protect and insure continuation of existing wild stocks.

Overview of Our Public Process

During February and March of 1993, biologists from ADF&G Sport Fish held 14 public meetings in large and small communities throughout Southeast Alaska with a wide variety of groups to discuss their concerns and determine if the angling public had information and/or similar concerns for trout stocks. Additionally, we distributed over 7,000 copies of an informational leaflet briefly outlining trout life history and our management concerns in newspapers around

Southeast Alaska, primarily to the smallest communities. We set up booths at each of the main boat shows in Southeast to talk with anglers and distribute the informational leaflet. The leaflet was distributed as well to everyone who reserved a U.S. Forest Service cabin at a cutthroat lake in 1992, and a questionnaire accompanied, requesting opinions on proposed management options.

Public response to our request for trout management input was generally supportive. Anglers concurred with the department's concerns and agreed that there was a problem with declining numbers and/or sizes of trout. Many anglers also highlighted specific systems where they had seen declining catches and/or sizes of cutthroat trout and steelhead. At the end of each public presentation, we distributed the trout questionnaire to evaluate public opinion and solicit suggestions on potential management options.

We received 192 responses to our questionnaires. Nearly 76% of the respondents favored a 14-inch minimum size limit, and support for bait restrictions was even stronger (80%) for cutthroat trout in fresh water. Most questionnaires (81%) were from Alaska residents; 19% were from nonresident anglers. Responses from both groups were strongly in favor of both the 14-inch limit and bait restrictions. Over 70% of the respondents were in favor of making all sea-run cutthroat populations catch-and-release-only. Nearly 60% favored special restrictions for the 13 lakes in Southeast Alaska that are known for their trophy-size cutthroat trout.

By fall 1993, the Sport Fish Division had developed a set of draft trout regulations and, through another series of public meetings, presented the management package to all communities with local Fish and Game Advisory Committees.

Concurrent with the public process to develop the trout regulations, the Division of Sport Fish initiated a separate planning process to evaluate steelhead regulations and public attitudes about future management strategies. At the time, the steelhead bag limit was 1 fish per day with 2 in possession and no minimum size limit. The Commissioner of ADF&G appointed a 9-member citizen committee to make recommendations on how to manage steelhead in Southeast Alaska. Committee members included steelhead anglers from Anchorage, Yakutat, Juneau (two members), Sitka, Petersburg, Ketchikan (two members), and Prince of Wales Island. This committee developed a survey that was sent to 1,768 steelhead anglers. The list of anglers surveyed included all respondents to the SWHS who had fished on a steelhead system in Southeast Alaska in 1992 or 1993.

The 678 returned surveys confirmed that most steelhead anglers felt steelhead should be managed more conservatively to rebuild abundance and provide continued fishing opportunity. When asked why anglers fish for steelhead, most answered that they liked to fish (55%) and enjoy the outdoors (35%) as prime reasons, while keeping a trophy or eating a steelhead were minor considerations (<10%). If restrictive regulations are necessary (i.e., steelhead populations continue to decline), most respondents preferred a catch-and-release-only management option (42% of the residents and 49% of the nonresidents); reducing the total harvest (daily bag limit) was a preferred (33%) second option (36% of the residents and 32% of the nonresidents). If there is a harvestable surplus of steelhead, 39% of the respondents preferred management options that include an annual bag limit (38% of the residents and 34% of nonresidents) and gear restrictions (34% of the residents and 32% of the nonresidents).

Adoption of new regulations

The Alaska Board of Fisheries (BOF) is responsible for enacting regulations, which conserve and develop the State of Alaska's commercial, subsistence, sport, and personal use fisheries. The BOF meets on a 3-year cycle for fisheries regulations in each region of Alaska and considers changes to regulations from individuals, groups, or by ADF&G.

In early 1994, new trout regulations were adopted in Southeast Alaska by the BOF, combining bag limits, size limits, and bait restrictions. A 12-inch minimum size limit for cutthroat and rainbow trout was implemented throughout the region to (1) provide protection for juvenile steelhead and sea-run cutthroat trout before they emigrate to the ocean, and (2) protect cutthroat and rainbow trout until the majority can spawn at least once. A larger size limit (14-inch minimum size) was adopted for areas with developed access and/or intensive fisheries, i.e., "high use." Under this more restrictive limit, all female cutthroat trout are protected from harvest until they have had the opportunity to spawn at least one time. A maximum size limit of 22 inches (fish greater than this size cannot be legally harvested) was also implemented to protect returning adult steelhead. In addition, a 10-month (November 16 through September 14) ban on fishing with bait was implemented in freshwater systems to reduce hooking mortality on trout and steelhead. The 2-month period in which bait is allowed provides anglers the opportunity to use bait when adult coho salmon are present in fresh water. A year-round bait ban was adopted in all areas where the 14-inch minimum size was implemented. More conservative steelhead regulations were adopted by the BOF: a minimum size limit of 36 inches, and a bag limit of 1 steelhead per day and an annual limit of 2 steelhead per year.

The regionwide minimum size limit provides a practical and cost-effective way to manage the numerous trout populations throughout Southeast Alaska without the need for detailed biological data on each system. However, because of diverse management situations, the BOF also provided several exceptions to the regionwide minimum size limit, including "high-use," "trophy" (25-inch minimum size limit), "stocked lakes," "small lakes" (9-inch minimum size limit), and "special lakes" (one catch-and-release-only lake and one lake with less restrictive harvest regulations).

Alaska Board of Fisheries Actions Since New Trout Regulations Adopted

1997 BOF Meeting

During 1997, the BOF again considered trout and steelhead regulations in Southeast Alaska. Thirty proposals related to trout and steelhead were submitted and discussed. There was general agreement that steelhead populations had not had time to respond to the new regulations and should be left unchanged, but trout regulations were more contentious. One of the primary concerns expressed by the public was that young anglers could not use bait and were being excluded from fishing. The board implemented a provision that allowed each of the primary communities in Southeast to designate a nearby lake at which the use of bait would be allowed. During 1997 the board asked ADF&G to evaluate cutthroat trout length at maturity in more lakes and report the results during the next meeting (2000). As a result, in 1997 and 1998, Sport Fish Division funded and conducted a study on cutthroat trout length at maturity at 21 lakes throughout Southeast Alaska (see Evaluation of New Trout Regulations below).

2000 BOF Meeting

In February 2000, the BOF received only 12 proposals that directly addressed trout or steelhead management in Southeast Alaska. Six other proposals addressed fishing methods, means or general provisions that might be applicable to trout or steelhead fishing.

ADF&G staff submitted a proposal requesting the BOF to reduce the regionwide trout minimum size length limit from 12 inches to 11 inches. This proposal stemmed from results of the maturity work the BOF requested in 1997.

The other 11 proposals included a mix of public requests. One asked the BOF to repeal existing trout regulations and return management to pre-1994 regulations. Another proposal would have repealed steelhead changes, and three others asked for lower size minimum size limits for steelhead in specific waters. Four proposals requested catch-and-release fishing in the Mendenhall River drainage and Montana Creek near Juneau.

The 1997–1998 Length at Maturity Study revealed that there was no significant difference between the percentage of mature female cutthroat trout at 11 inches or 12 inches. On the basis of these results, the BOF adopted the department's recommended 11-inch minimum size limit.

The BOF enacted three trout regulations during its 2000 meeting relating to the "high-use" (14-inch minimum size limit) category. The BOF adopted regulations that: (1) extended the "high-use" area along the Juneau road system to a line ¼-mile offshore; (2) moved three Prince of Wales Island lakes into the "high-use" category; and (3) removed Thayer Lake on Admiralty Island and three Sitka area streams from "high-use" category and placed them under general regionwide trout regulations.

2003 BOF Meeting

During the 2003 BOF meeting, 9 proposals dealing with trout and/or steelhead were discussed; 4 were submitted by ADF&G. Most of the proposals were seeking more restrictive gear regulations in trout and salmon waters; i.e., requesting waters be made fly-fishing-only or single barbless hooks. One ADF&G proposal dealt with removing the ability of anglers to legally harvest adipose clipped steelhead in any waters; this proposal was submitted to simplify existing regulations and eliminate the perception that hatchery fish were available throughout Southeast Alaska. Another ADF&G proposal requested a year-round bait closure on several anadromous lakes on the Juneau road system. The other two ADF&G proposals requested specific exceptions to the regionwide 11-inch size limit: (1) that Winstanley Lake be managed as a "high use" lake with a minimum size limit of 14 inches, and (2) that the minimum size limit at Lost Lake be reduced from 11 inches to 9 inches.

All ADF&G proposals with the exception of Winstanley Lake were adopted by the BOF. The only public trout proposal adopted by the BOF made unbaited, single hook, artificial lures the only legal gear in the Karta River drainage. Karta River is the one of the most heavily fished steelhead streams in southern Southeast Alaska.

Evaluation of New Trout Regulations

The backbone of Southeast Alaska trout regulations is the concept that wild populations of trout will be adequately protected if a majority or, in higher use areas, all cutthroat trout can spawn at least once, or have the opportunity to spawn at least once, before being available for harvest. There are two components to evaluating the new trout regulations: (1) is the minimum size limit appropriate for a particular water body; i.e., does the water body produce trout of that size? and (2) does the regulation adequately protect the trout stocks?

At the time the new trout regulations were adopted in 1994, an obvious need existed for more extensive length at maturity data for cutthroat trout from a variety of populations and lake types throughout Southeast Alaska. During the past 10 years, most of the public comments, complaints, and BOF proposals have been about increasing the opportunity to harvest more trout. Advisory Committee reports and public testimony given at the 1997 BOF meeting, for example, indicated current regulations in some lakes were too restrictive. Anglers have provided testimony and comments that they believe that some lakes have never produced any legally harvestable trout; that is, no trout ever attain the minimum size limit of 11 inches. In general, we recognized that length and/or age at maturity in fish populations was an expression of the growth of individual populations (Tipple and Harvey 1990, Clark 1992) and the type, size, and location of the lake (Schmidt 1994, Harding 1995). Below is a brief review of our 1997–1998 length at maturity study and how this study was used to evaluate our new trout regulations.

Cutthroat Trout Maturity Studies

The goal of the "length-at-maturity" study was to estimate, within 1-inch size increments, the proportion of female cutthroat trout that were sexually mature in typical lakes in Southeast Alaska. With this in mind, ADF&G biologists selected 21 lakes spanning the range of lake and fish sizes present in the region. We believed these lakes were, in general, not heavily exploited, so that a range of fish sizes were present, and that the sampling would not jeopardize the health of the populations.

Sampling occurred between late September and mid-November in 1997 and 1998. While cutthroat trout in Southeast Alaska typically spawn in early spring, gonads must be in an advanced stage of development by fall if the fish are going to spawn in the succeeding spring (Behnke 1992). Test sampling at Florence Lake during July, August, and September of 1997 (Foster 2003), and at Little Lake on Prince of Wales Island during September 1997 indicated that sexual maturity could be determined with confidence by mid-October. Samples were thus collected late enough in each year so that maturity stage could be easily determined, but before inclement weather, freezing conditions, and spring spawning occurred. Our sampling included 5 sea-run (mixed stock overwintering) lakes and 16 resident only cutthroat trout lakes.

Samples in each lake were collected by using three gear types: floating and sinking variable mesh gill nets, hoop traps, and hook-and-line gear. Whenever possible samplers strove to: (1) sample similar numbers of fish with each gear type; (2) sample the diverse range of lake habitats and depths (<30 m) present in the lake, and (3) meet overall sample size requirements for each 20-mm size interval. Target sample sizes for 1997 were not attainable in some small lakes, but the 2-year sampling design allowed samples to be pooled across years (i.e., 1997–1998) in lakes with similar characteristics, to obtain the desired (provisional or final) statistics. Each cutthroat trout captured was measured and a subset was sacrificed and sampled for sex and maturity following procedures described by Downs et al. (1997).

From the 21 lakes studied, we sampled 1,864 female trout ranging from 5 to 17 inches in total length. Sixty percent (60%) of the female trout we sampled were mature in the 11-inch length category, and 62% of the females were mature in the 12-inch minimum size limit (Figure 1). As a result of this finding, we recommended a reduction in the Southeast regionwide minimum size limit from 12 to 11 inches; this recommendation was ultimately adopted into regulation by the BOF in 2000. Below 11 inches, the sea-run cutthroat maturity rate falls quickly; at 10 inches, only 28% of the sea-run females were mature. Because many of the most productive lakes with cutthroat trout in Southeast Alaska contain sea-run cutthroat, setting the minimum size limit below 11 inches could put these populations at risk. An additional finding of this study was that cutthroat trout have fewer eggs per ripe female (or lower reproductive potential) than previously believed: on average, an 11-inch female cutthroat has only 263 eggs.

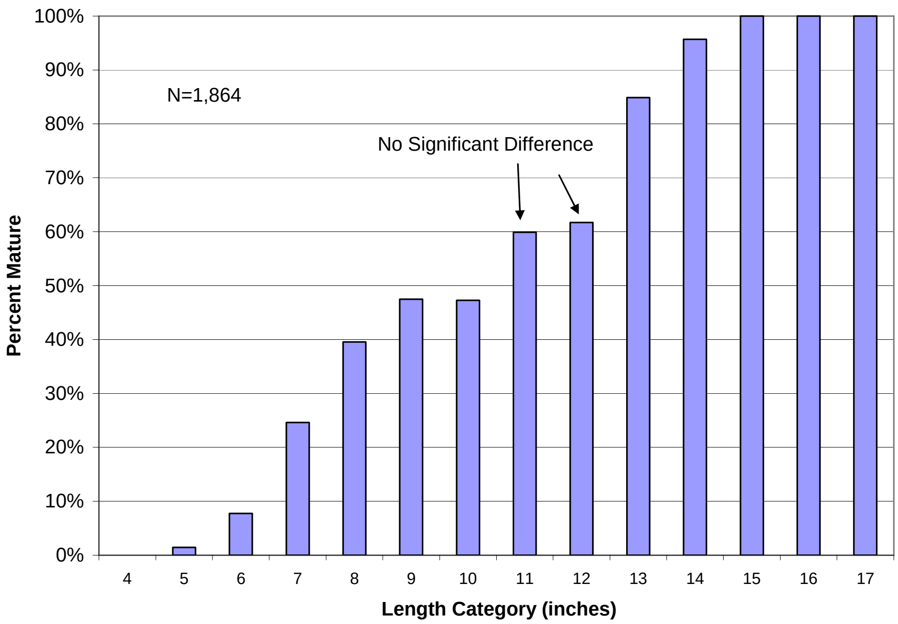

Figure 1. Percentages of female cutthroat trout that were mature in 21 Southeast Alaska lakes sampled during 1997 and 1998.

Recommendations for Future Work

Fisheries managers must be aware that there will be continued pressure to “relax” the conservative regulations, and they must therefore design appropriate research projects to collect data to defend and maintain the regulations as well as collect lake-specific maturity information. Any future length at maturity projects should incorporate ultrasound technology as a non-lethal method of sampling (Martin et al. 1983).

In order for any sport fish regulation to be effective, there must be a high degree of compliance. ADF&G biologists are concerned that substantial illegal harvest may be occurring in Southeast Alaska, especially in some of our remote “fly-in” lakes. There must be ongoing efforts to educate the public about our regulations and to keep the regulations posted in these remote sites.

Acknowledgements

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Writings on Angling and Ethics

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ABSTRACT—There is a growing body of information that fishing as sport is as ancient as fishing itself. Many of the world's cultures have ancient angling traditions. According to the limited written record, fishing as sport began in Europe by the Roman era and a thousand years earlier. The popularity of fishing with rod and line in medieval Europe appears to have pre-dated the development of the sport in the British Isles by a century. In America, our first fishing publication is a defense of fishing with rod and line as recreation. The detractors of angling are equally ancient. Discussions of the lack of pain in fish, the questionable ethics of harassing living creatures for our enjoyment, and the idea of releasing a portion of one's catch date back centuries. Managers who serve a diversity of cultures should understand the antiquity of the sport they manage and honor older and different traditions if they want to safeguard native trout fisheries and gain acceptance from recreational anglers.

Early History of Sport Angling

Three thousand years ago, Asian sport fishing included bamboo rods, silk lines, feathered hooks, and barbless hooks (Radcliffe 1926). There is evidence that the reel was in use in China centuries before it was "invented" in the west (Trench 1974). Even so, fishing traditions that influence American angling today is based on western traditions. The early distinction between recreational angling and subsistence fishing in history is noted by Charles Trench in *A History of Angling*. The distinction is made perfectly clear by two Egyptian drawings: one, of about 2000 B.C., shows a man fishing who is poor, perhaps, or a professional fisherman. Another, dating from about 1400 B.C., shows a gentleman of leisure angling

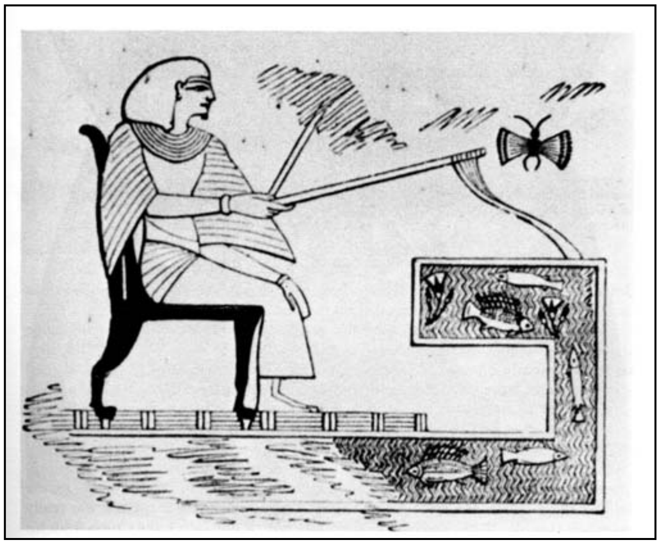


Figure 1. Charles Trench, a history of angling. Another dating from 1400 B.C shows a gentleman of leisure angling.

Early images imply that angling for food was different from recreational fishing. A poem by Theocritus, written in approximately 280 B.C. blurs this distinction (Hine, 1976). This is the first Big Fish story. "… Holding on tight to the pole, which was bent in my hand by the motion, as I extended my arms leaning forward I found it a struggle, How was I going to land that big fish with my flimsy equipment…" In this translation, *The Fishermen* reads as a recreational story with the stalk, the hook-up, and the fight on light tackle. Fishing from the earliest times was fun, even when it was for food. Aeilian, who is credited with the first writings about fly fishing (200 A.D.), also describes fishing with hook and line as "being the most skillful and becoming for free men…"(Trench 1974). The Roman poet Martial, (100A.D.) mentioned fishing with a fly. An early translation reads: "gifts are like hooks; for who does not know that the greedy sea-bream is deceived by the fly he has gorged?"(Ker 1978)

During the Middle Ages, fishing grew in its importance as a food resource in Europe. The growth of the Catholic Church and the subsequent rise in the number of holy days annually resulted in between 140 and 160 days each year when fish were the only flesh consumed (Hoffman, 1997). Fishing, and possibly fly fishing, became the sport of the common man during this time. Fishing with the "vederangle", or feathered hook, appears in German literature in 1210. Wolfram Von Eschenbach's hero Schionatulander wades into a mountain stream, casting for trout and grayling (WWW.flyfishinghistory.com).

Humanism began in the first half of the 14th century in Italy. Many writers trace its roots, and the emergence from the Dark Ages, to Francis Petrarch. His writings in the vernacular tell of country life, fishing, and climbing mountains.(Shepard, 1930) Petrarch is credited with the rise in vernacular literacy in Italy and the growing interest in life in the out of doors.

Perhaps the earliest naming of fishing done with rod and line as sport is found in Peter Crecentrensis' middle English translation (1600) from the Italian *The Countrye Farm* (1307). Chapter XVI begins with an apology for the previous chapters on fish husbandry and harvest by net, drain, or poison, and continues...

Figure 2. Four centuries of sport in America, H. Manchester. The recreations of the gentlemen of Virginia, 1607.

I will wade a little further in this art and shew you the manner of taking all sorts of fish by the angle, which is the most generous and best kind of all other, and may truly be called the Emperor of all Exercises. To speak then first of this art of angling or taking of fish with the angle, you shall understand that it consists of three especial things, that is to say, in the instrument which is the angle, in the instrument which is the bait, and in the true use of them both together, which is the seasons and time of year for the sport.(Country Farm 1307)

The author indicates how popular angling had become in the 14th century when he writes “But because the trouble of making (hooks) is a little noisome, it shall be best to buy them from such as make a living or trade thereof…”

Hoffman establishes that vernacular literacy had reached 20 percent in Italy by the 1500s and in England and Germany by the 1600s. This expansion in literacy led to changes in what was published. Works with topics as diverse as the plague, hair color, and fishing survive. The Heidelberg Fishing Text (1493) is a how-to-fish handbook in 27 chapters that was copied and altered to meet local fishing situations across Germany in the early part of the 16th century. It appears as part of the Tegernsee Fishing Advice. This collection of fishing materials written by monks in the Tegernsee Abby begins with more than 50 fly patterns. Beyond their early date and the fact they were copied, modified for local fishing, and distributed, the true significance of both works is that they were written in the vernacular. They were intended as advice for everyman.

Roman water law dictated that all flowing waters belonged to all freemen in common. This practice carried into the late Middle Ages. The birth of industry, especially in England, even on a local scale, disrupted this public access. In the Domesday book of 1086, there appear 5,624 listings of mills in England. Certain streams had a density of one to three mills per mile. (Getzler 2004) The restriction these mills and their dams placed on the commoner’s right to fish became so onerous that the Magna Carter banned weirs except along the coast. Fishing in church waters supported by the clergy appears to have been delayed in coming to England. When it did, the church brought its understanding of the importance of fish as food and recreation with it.

It is interesting to note, as Francis Francis did, “Grayling are supposed not to have been indigenous to England, but to have been transplanted hither by the monks...”(Francis, 1867). The monks may not have imported grayling, but most monasteries where built near graylings streams. Grayling are of note because they are at their prime as a food source during the winter months.

With the rise of the middle class in England an earlier egalitarian fishing tradition was lost. Flowing waters became a source of power and a crucial resource of the industrial revolution. By 1700 there existed between 10,000 and 20,000 mills in England. The density of up to five mills per mile near some industrial centers multiplied during the industrial revolution of the 19th century. As part of Great Britain’s rigid social structure, sport fishing became a class specific activity. Access to and participation in fly fishing, associated with clean, flowing waters, denoted status. Private waters were the preserve of the gentle classes. In England, this restriction of access provided impetus for fly fishing as a field rich with technical innovation, literature, and art.

England was not the sole source for the renaissance in early fishing. The more egalitarian nature of fishing on the Continent was captured in the first literature associated with the sport. Many writers claim more has been written about angling than any other field sport, yet few angling text are “Literature.” Most are extensions of the ephemera of magazines; detailing the how, when, and where of angling. For angling writing to exceed this, it must reach beyond fishermen to a wider audience. The first work to achieve this in English is Izaac Walton's *The Compleat Angler* (1653). Of an earlier date and publication in Spain, Fernandro Basurto's *Dialogo* (1539), is regarded by many as the first true literature of sport fishing. The contrast in persons who fished and their relationships in both England and Spain is made clear in the difference between the protagonists in the two works. In Walton's "*Compleat*", two Gentlemen discourse over several days about the sport. Basurto's *"Dialogo"* also takes the form of a conversation between two protagonists. One is a young, uninformed, aristocratic hunter, the other an older angler. The angler is well read and well traveled, but poor. He declares that if there were but one river in the world, and that thousands of miles distant, he would fish it. He is the first trout bum: he lives to fish, and if he could not, "death would fish him" (Hoffman, 1997).

Western angling traditions diverged with industrialization in England. The Continent's populist sport of fly fishing became the providence of a more moneyed class. In England, the system of access, rules of sport, and harvest were structured to both keep fly angling exclusive and develop the courtly, gentlemanly sport of the later 19th century. This distinction between fishermen of different classes runs up against the abundance of resources in America and is changed once again.

"I believe I have you now, Sir!" Daniel Webster's great trout

American Angling

Fishing as sport moved in two directions in America in the 17th and 18th centuries. The first was the popularizing effort of the commoner angler; the second was the sporting traditions of the British officer class. The early literature of fishing in America was that of the visiting British, allowing the admonition by William Chatto in *The Angler's Souvenir* (1835), "Brother Jonathan is not yet sufficiently civilized to produce anything original on the gentle art"(Schullery, 1987). This lack of fishing writings has led some to say that angling, as sport was not popular in early America.

The historical record shows differently. In 1619, *Recreations of Gentlemen in Virginia* depicted an angler attempting to take a very large fish (Manchester, 1991). In the 1640s, Boston protected the public's rights to fishing waters. In 1659, Governor Peter Stuyvesant, when proclaiming a day of fasting, wrote: "We shall prohibit all exercise and games of tennis, ball playing, hunting, fishing,...." If America has a counterpart to England's Dame Juliana Barnes (late 15th century), being the first to write of ethics and fishing as sport, it is the Reverend Joseph Seccombe. His *A Discourse utter'd in Part at Ammauskeeg-Falls, in the Fishing Season* (1739) explains that the business of America is business. The Lord is pleased with the fruits of our labors, however, He gives but one day for renewal each week. According to Reverend Seccombe, the best way to re-create oneself to do the work of the Lord in the marketplace is to fish on the Sabbath (Milne Collection UNH).

Fishing clubs were established very early in Philadelphia and New York. Five clubs existed in Philadelphia before the revolution. As Paul Schullery wrote about the colonial angler, “What we know already assures us that they were there, and that they knew as well as we how to enjoy fishing, but there is little flesh on the bones; we know too few names, too little about their tackle and their exploits, and much too little about their connections with their European counterparts” (Schullery,1987).

The American struggle as depicted in myth and letters was man against nature. The general belief that American sport fishing began with the close of the frontier had to do with the transfer of the class struggle in Europe to the struggle against wilderness in America. As Schullery pointed out, “The other argument that colonists had no time for fishing, because they were too embattled by bears, Indians, and other survival problems, is also in error.”

The belief in the expanding frontier and the man-versus-nature myth was, perhaps, best rendered in the novels of James Fenimore Cooper. Mark Twain once remarked Cooper’s boats didn’t fit in his rivers (Twain, 1895); however, Cooper’s character Leatherstocking was the innocent confronting and subduing wilderness. Cooper’s writings were popular because his characters spoke to the beliefs of his age. An element of this myth was that the innocent had no time to recreate when faced with the burden of taming wilderness.(Smith, 1970) The truth is that lives were lived in the westward expansion. The peoples of Europe brought their older, more egalitarian fishing traditions with them when they immigrated to America, and those traditions helped us fish our way westward. From fishing with decoys in Minnesota to cane poles and bird flies in the south, there exists a rich, culturally diverse, history to regional angling in the United States. As Schullery said, we know “much too little about their connections with their European counterparts.”

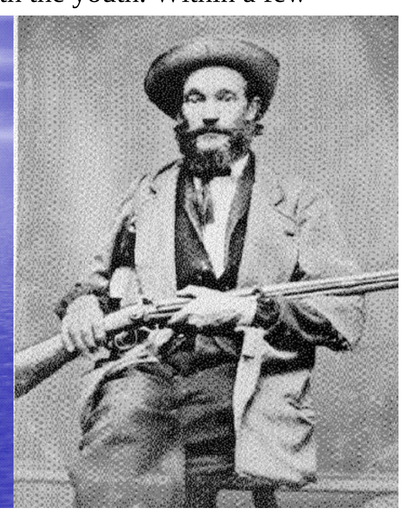
There were three angling texts published prior to the Civil War that set the stage for the popularization of field sport. George Bethune’s American edition of *The Complete Angler* (1843) is noteworthy because Bethune’s notes provide a decidedly American air to the work. The first American text on angling was New York tackle dealer John Brown’s *American Angler’s Guide* (1845). While Brown objected to the idea that we owed our angling traditions to England, much of his work continued the old English tradition of lifting passages or whole sections of earlier work from older British authors. Perhaps the author with the greatest influence on angling in America prior to the Civil War was Henry William Herbert, author of *Frank Forester’s Fish and Fishing of the United States* (1849) and *Frank Forester’s Complete Manual for Young Sportsmen* (1854). It is somehow appropriate that “Frank Forester” was an expatriate Briton who brought his understanding of field sports with him. Even so, the next generation of American writers had their locally published works, of British invention, to build upon.

The growth of the Romantic Era in America during the middle years of the 19th century, the immigration of legions of anglers from Europe, the bloody legacy of the Civil War, and the birth of industrial tourism combined to change the public perception of field sports. This led to a tremendous increase in sport fishing’s popularity during the last half of the century. “Uncle Thaddeus Norris”, who is known as America’s Izaac Walton, published *The American Angler’s Book* in 1864. In his introduction “to the reader,” Thaddeus Norris declared that he wrote “(w)ith a view to filling up the blank left by my predecessors,...correcting some erroneous ideas...not only concerning fish but the adaptation of English rules and theories ...to our waters...”(Norris 1864). He does so admirably. At a time when industrial growth and westward expansion dominated popular thinking, Uncle Thaddeus spoke against pollution of the nation's waters and for conservation and wise management of fisheries. Uncle Thaddeus was, perhaps, the first American writer to release fish nearly as often as he kept them, and to intentionally fish the floating fly.

Figure 3. Paul Schullery, American Fly Fishing, Murray's Fools.

Many fly fishers believe that if Thaddeus Norris is our Izaac Walton, then Theodore Gordon is our Charles Cotton. Gordon's contribution to entomology and fly tying has been elevated to the status of myth. He had little to say on conservation. One understated reference on the need to limit harvest was; "If everyone is to have equal opportunity, then the rank and file will have to exercise some self restraint." (FG, Oct. 12, 1912). Gordon heralded the coming great age of fishing writing in America. In the decades between 1900 and 1940, much of our best angling literature was written and the rules of our sport expanded. This remarkable growth in letters came about because of the revolution in attitude toward nature after the Civil War.

The period between the Civil War and the turn of the Century saw a flowering in American field sports. The public embraced nature as a healer and a source of renewal. One of the most influential authors of the post war era who proselytized for nature as healer was William Henry Harrison Murray, a minister from Boston who camped in the Adirondack Mountains each summer. He was known as "Adirondack Murray." In his introduction to *Adventures in the Wilderness* (1869), Murray related the tale of a sickly youth from the city, recently arrived at the Adirondacks, intent upon being carried into the wilderness to die. One guide refused his request: the guide would not want to have to carry his body out. Another guide took pity and set off with the youth. Within a few days, the balsamic airs started to heal him. After weeks in the wilderness, he returned to the bosom of his family, well and whole. This vision of nature as healer was repeated by the next generation of scribblers, notably George Washington Sears, who wrote under the pen name 'Nessmuk.' Nature never did cure "Nessmuk" of his tuberculosis; even so, he published popular letters in Field and Stream magazine in the 1880s touting the healing powers of Nature.



George Washington Sears, a.k.a. "Nesmuck"

This vision of nature as a source of renewal was capitalized on by the railroad companies. They were desperate to market the lands received for building their lines across America. The railroad owners had to find a way to generate revenue from their lines. Part of their solution was to market the wilderness as healer. “Murray’s fools,” hoards of urban dwellers looking to escape intolerable summers, eagerly fled to new lodges and faux wilderness on trains. This was the birth of today’s industrial tourism, and remains an indicator of the death of wilderness (Limerick 1987).

A willing public made the leap from Adirondack Murray to John Muir, T. R. Roosevelt, and Gifford Pinchot. Muir sought nature to heal him after a loss of sight in an industrial accident and took his first great hike to the Gulf. Roosevelt traveled to Montana to be in on the killing of the last buffalo and heal his frail health. Pinchot flyfished on a camping trip with his father while the family stayed at one of the great Adirondack camps first popularized in Murray’s writing. The belief that nature is a healing agent is a crucial change in both the growth of environmental thought and the relationship between the angler and his quarry.

The speed with which the public attitudes toward wildlife changed at the close of the 19^{th} century may be seen in the story of *Stickeen,* by John Muir (1909). Muir owed his popularity as a naturalist writer to the ease with which he anticipated public attitudes. He had to moderate his beliefs about animals throughout much of his writing career (Limbaugh, 1984). It was not until Muir became America’s premier nature writer that he dared to break with his readers and publish what he truly believed.

In 1880, on his second voyage through Southeast Alaska, Muir took a day’s walk on the glacier at the head of Taylor Bay. Muir may have been accompanied that day by a small, mongrel dog. When Muir first related the difficulties of the day, which culminated in a hazardous escape across a narrow ledge of ice, he failed to mention the dog. Over the ensuing years, he told the tale of his narrow escape to children and, then, adult audiences. Slowly the dog entered the story and grew in importance: Muir’s long abiding belief that animals have souls, emerged. In the final version, first published as a magazine article in 1897, Muir and the dog Stickeen share a deep bond. Muir related that he had come to recognize through their shared adventure the divine in all living things. During the twenty-seven years between the event and the book, Muir gauged that his reader’s sensibilities toward animals had changed to the point that he could now publish his long held feelings.

The need of the country to heal from the Civil War, the advent of industrial tourism, and the remnants of the Romantic Era combine to popularize wilderness in the final decades of the 19^{th} century. Given the backdrop of American’s continuing belief in the need to subdue nature, this rapidly emerging belief in nature as healer leads to conflicting attitudes toward wildlife. Manifest Destiny and the burden of our frontier myths insisted that we become the masters of nature. The romantic vision quietly urged that Americans concerned with nature regard the living targets of bloodsports as equal and worthy opponents.

Toward an Angling Ethic

Only an epigram of Martial’s from the first century, dealing with the release of mullet under three pounds, (Ker 1978) and a line from *Piers Ploughman* (1300-1400) to release small fish may predate the mythic Dame Juliana Bernes’ admonitions about ethics. Her final commandments in *The Treatise* were to respect private property, take only those fish you will consume, and do all you can to nourish the fish you seek (McDonald, 1963). It was a fine start toward today's code of angling ethics. In the early literature of angling, the Dame stood nearly alone in advocating for a general code of behavior. John Denny, in *Secrets of Angling* (1613), listed twelve virtues of the angler, which hint at appropriate behaviors. Bethune's edition of Izaac Walton and Charles Cotton's *The Complete Angler* nowhere detailed appropriate behavior; however, their contribution to ethics was to show how angling makes for a good life. The narrator's pupil Venator learned the generous spirit of angling as much as he did the particulars of the sport.

Early arguments against angling compared its rustic behavior to the virtues of parlors and gaming houses (Dennys 1613). This was part of the popular vilification of field sports as portrayed in Fielding's *A History of Tom Jones* (1749). By 1828, Sir Humphrey Davy felt obliged to spend the first several pages of *"Salmonia"* defending the sport of angling from its detractors. "Hal. I have already admitted the danger of analyzing too closely, the moral character of any of our field sports;..." (Davy 1828). Lord Byron, in *The Cantos of Don Juan* (1821), wrote: "And angling too, that solitary vice, whatever Izaac Walton sings or says; the quaint, old, cruel coxcomb, in his gullet should have a hook, and a small trout to pull it."

Fishing as a blood sport was discussed in the 19th century, and the need to release at least a portion of one's catch was well established in England during that time. In *Salmonia*, after discussing the cruelty of the hook, Davy's protagonist Halieus says, "...every good angler, as soon as his fish is landed, either destroys his life immediately, if he is wanted for food, or returns him into the water." He continued with comments on the survival of fish released and their poorly developed nervous system for sensing pain. Davy wrote that fish under two pounds should be returned to the water. Francis Francis, in *A Book on Angling*, wrote, "I hate a man who slaughters kelts and ill-conditioned fish more than any other species of poacher going. What good does it do him? He has had his sport. Let him be satisfied; and let the poor beast live and grow fat and healthy, and don't take a mean advantage of starvation and illness." (Francis, 1867)

Fredrick Halford, in *The Dry Fly Man's Handbook,* provided very modern instructions on how to handle and release fish not kept as food. He concluded, "A fish just up to the limit should invariably have the benefit of the doubt and be restored to its native element."(Halford, 1913) In chapters on fisheries management, Halford spoke for conservative size and bag limits. He also provided an argument for releasing undersized fish: "Let there be no mistake about it! The pot-hunter wishes to kill all he can, regardless of size, and the sportsman is not only willing to return any below the legal limit of the water, but exercises the greatest care both in extracting the hook and returning the fish to the water."

Ethics in America


Uncle Thaddeus Norris

The superabundance of fish and game resources in America during the colonial period and during western expansion allowed anglers to have no regard for the health of populations of wild fish. Americans took full advantage of their right to fish. Thaddeus Norris wrote of anglers who routinely harvested 500 plus brook trout in a single day's fishing.

Even so, there were persons who felt that fishing, as a diversion was cruel. The Reverand Seccombe addressed this in 1739: "(in their Apprehension)...He that takes Pleasure in the Pains and Dying Agonies of any lower Species of Creatures is either a stupid soul or a Murderer in Heart" (McPhee, 2002). Thoreau began as an avid angler. He evolved from being both hunter and fisher, to fisher only, to being revolted by any blood sports (Owen, 1981). In *Walden* (1854) he wrote, "I cannot fish without failing a little in self respect...Yet with every year I am less a fisherman,…at present I am no fisherman at all. But I see that if I were to live in wilderness, I should again be tempted to become a fisher and hunter in earnest."

Murray spoke of the healing power of nature while he related taking forty shots to destroy a loon. He also wrote of releasing half of his catch at the side of the boat.

The movement on the part of anglers to release a portion of their catch became specific with Uncle Thad. He expressed his concern for the declines in numbers of fishes in American waters. He blamed pollution, timber harvest, farming, and mining, as well as urban forces for these declines. He then detailed huge harvests by anglers of hundreds of pounds of trout in a day. Norris implied disgust for this waste, and wrote of releasing nearly as many fish as he kept.

Regardless of the growth of angling literature and concern, sport fishing in America in the middle decades of the 19th century was becoming bleak. As early as 1856, George Perkins Marsh had reported to the Vermont Legislature "mills and factories dammed streams, polluted waters, and killed fish" (Taylor, 1999). Marsh implicated farming and logging. He concluded: "It is enough to say that human improvements have produced an almost total change in all the external conditions of piscatorial life." By the time "Murray's Minions" descended upon the wildlands of eastern America, there was little left. The Eastern brook trout was soon fished out and European browns and rainbows had not yet taken hold. Hatcheries became the panacea for ailing fisheries.

From the admonitions of Zane Grey at the Long Key fishing club to release most of your catch, to the efforts of President T. R. Roosevelt to set aside much of the remaining forests for the public good, the public soon came to support conservation. The turn of the last century was the time when anglers stepped forward to rescue their sport. In the next decades, most angling authors recognized their responsibility for anglers' impacts. Writings on angling and angling ethics flourished.

Louis Rhead might have played a pivotal role similar to Muir's in angling and conservation if he had been more moderate in his vision. Rhead wrote the first book on stream entomology in America, published articles on the nymph and successful nymph fishing techniques decades before their time, and included in a very popular book on bait fishing a full chapter on the need for conservation and the question of the ethics of angling. He was also credited with bringing the barbless hook into fashion in the first decade of the century. Rhead was regarded poorly for many years more because of his personality than his writing. He is gaining in popularity again as American anglers have come to respect innovation over tradition. During the first half of the 20th century, many fishing writers chose to copy or build on his work.

The contrast between Muir's continuing popularity and Rhead's decline speaks loudly to the tradition of a dialogue of ideas in fishing writing. During the years between 1900 and 1939, authors addressed the question of angling ethics in small steps. The use of barbless hooks, the fish hog, the need to support conservation, all were discussed in fishing magazines and books. An example of the evolution of ideas on ethics in print is growth in interest in catch and release. During the first decades of the 20th century, there were many references to releasing fish printed.

Theodore Gordon remarked on the growing practice of releasing fish. "Some say it is well to kill off the big fish. I doubt this greatly" (F&G magazine, Aug 18, 1905). And, "I know Mr. LaBranche by reputation, and his ideals are high. He fishes the floating fly only and kills a few of the large trout. All others are returned to the water.... I fancy that a trout should be big enough to take line from the reel before it is considered large enough to kill."(McDonald, 1947)

In *Streamcraft* (1919), George Parker Holden took time out from describing the habits and lures of trout and bass to declare "not the least of the beauties" of fly fishing is that the quarry is hooked "lightly through the lip." Holden then instructed on how to release fish easily, with minimal damage. He quoted Mr. Harold Trowbridge (*Outlook* magazine, Aug. 6, 1919) extensively on the use of barbless hooks. Here was perhaps the first documented example of catch and release with no intent to harvest:

"In one morning's fishing out of fifty successive fish which I hooked I found it necessary to take only three out of the water in order to release them from the line. Two dropped off as they came over the side of the boat, and only one required an instant's touch before the hook could be slipped from its jaw."(Holden, 1919)

Holden declared: "Do not be afraid to join the slowly growing fraternity of those anglers whose password is 'We put'em back alive!'" and "(s)ince the impulse that Mr. Pulsifer's article gave to this movement, barbless hooks both bare and dressed have come into quite general use..."

Hewitt's Handbook of Fly Fishing (1933) touched briefly on releasing fish in the section on "Articles Carried in Pockets":

"It is surprising what freedom and relief one feels when the basket is left home. I rarely carry one any more, as I seldom kill more than one or two fish for a day's sport, knowing only too well how long it takes to grow these fish and how few of them are in any stream. I do not want to injure my own sport or the sport of others in future."(Hewitt 1933)

In 1936, Gifford Pinchot published *Just Fishing Talk*. He referred repeatedly to releasing fish.

"We love the search for fish and the finding, the tense eagerness before the strike and the tenser excitement afterward; the long hard fight, searching the heart, testing the body and soul; and the supreme moment when the glorious creature, fresh risen from the depths of the sea, floats to your hand and then, the hook removed, sinks with a gentle motion back from whence it came, to live and fight another day."(Pinchot,1970)

These writings and many others led to Lee Wulff's famous "Game fish are too valuable to be caught only once." And "The fish you release is your gift to another angler and remember, it may have been someone's similar gift to you."(Wulff 1939)

I have only scratched the surface in this attempt to document the early discussions of ethics and releasing fish. It seems lately that every old book, every early article, every piece of ephemera I read has some reference, however small, to the appropriate behavior of anglers towards fish and each other. The works cited in this paper are simply representative of the discussions of their time. The questions asked today about angling ethics, fish feeling pain, and catch and release have been discussed by anglers and the non-fishing public for centuries.

Skipping far ahead in the continuing dialogue in print about the nature of angling ethics, I would like to recommend the final chapter in Roderick Haig-Brown's *A Primer of Fly Fishing* (1964). Just a few lines of introduction will do: "There is, I think, not much point in being a fly fisherman unless one is prepared to be generous and fairly relaxed about it all. Competition has no place at the streamside...The generosity I am thinking of is an attitude, a whole approach to the whole subject. It implies generosity to other fishermen, to the fish themselves, to the water and surrounding in which they live" (Haig-Brown, 1964).

Let me conclude with a comment from Marty Sherman: "Today's biologists and fishery managers need to get away from their computers, and go fishing with an appreciation of the mystique and traditions of our sport to understand why anglers and fishery conservationists are so emotionally involved in these magnificent resources. Beneficial partnerships can result when professionals and their publics can build positive relationships. With this kind of a base, the angling community can be a strong advocate for scientific fishery management in the political arena where professionals fear to tread."

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Effects of Increased Angler Use on a Native Cutthroat Trout Population in Slough Creek, Yellowstone National Park

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ABSTRACT—Catch and release has been the method of choice for fishery protection in Yellowstone Park for several decades and is now mandated parkwide for native species by National Park Service (NPS) regulations. At some of the more popular fisheries, the number of anglers has increased dramatically as catch and release angling became more accepted. Trail access to many of its backcountry areas and a reputation for an exceptional native cutthroat trout population make Slough Creek an ideal angling stream. Recreational use in the area increased by nearly 50% during the early 1990s, and by 1994 Slough Creek was second only to Yellowstone River in terms of annual angler use. Park managers became concerned that the high levels of visitor use (including angling) at Slough Creek were beginning to have a significant negative impact on the fishery and riparian resources; however, electrofishing surveys begun in 2001 failed to reveal population-level changes since the previous survey in 1988. A high percentage of the fish captured during our surveys had hook scars attesting to the recatchability of the Yellowstone cutthroat trout. These electrofishing results indicate that the cutthroat population in Slough Creek has remained vigorous even during extreme drought years. Many of the negative impacts to the visitor experience seem to arise solely from individual perceptions of an overcrowded fishing area, because catch rates have remained high despite increased use. Of far greater concern to NPS fishery managers is the recent capture of rainbow trout in an area previously presumed to be isolated from hybridizing species.

Factors Affecting Special Angling Regulations

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Extended Abstract

Special angling regulations have been used successfully to protect and rebuild fisheries in many regions of the USA and Canada, but it is important to recognize their limitations (Gresswell and Harding 1997). For example, when special regulations are successful, hooking mortality is usually low and the probability of recapture is high. Unless angler harvest represents a major portion of total mortality, reductions in angler harvest through special angling regulations may not have the desired effect. Where the environment limits growth, fish may not attain large sizes even when there is no angling. Furthermore, even when a fish population is protected from overharvest, arbitrary size targets or success rates may not be attainable in the sport fishery. Although densities may be high, species (or segments of a population) that are not vulnerable to angling can depress overall angling quality. In cases where there are a variety of species (stocks) in a fishery, unequal susceptibility to angling may also lead to unintended consequences.

It is apparent the success of special regulations varies with species, communities, and specific habitats. Although it may be possible to generalize for some species, response to particular regulations may be different when other species are present. Furthermore, habitat variables that influence growth, mortality, and distribution can influence the response to regulations even when biological assemblages are similar. These factors underscore the fact that agency and angler objectives should be concordant with the target species and site-specific environment prior to the implementation of special angling regulations.

Success of special angling regulations is often contingent on the size and age structure of the target population. To be effective, size limits must protect a significant portion of mature adult fish assemblage. Sometimes focusing harvest on a segment of the catchable population that has not become fully recruited to the fishery (maximum-size or slot-size limits) can provide sufficient protection. On the other hand, the size of fish available for harvest may not be acceptable (too small) to anglers. The potential biological outcomes of a regulation can be examined using simulation modeling; however, it is still important to monitor after the regulation is initiated. If regulations cause major changes in size distribution of the catch, size limits may need to be readjusted.

Public support and angler compliance are critical to the success of special angling regulations. It is important to consider angler preferences when developing new regulations, but at the same time, it is important to recognize the complexities of values among anglers and stakeholders. For instance, management responsibility extends beyond immediate constituencies to future generations of anglers and non-anglers alike, and therefore, the ecological basis for management should be clearly communicated.

It is commonly the responsibility of fishery managers to inform the public of resource problems, generate support for general management goals, and integrate

diverse values and opinions when developing management actions. Furthermore, a broad information base and a strong public education program are integral to successful management, and continued monitoring is needed to determine if future adjustments are required. Proclamations of success or failure of a particular special regulation are no longer sufficient. Instead, managers must synthesize factors related to site-specific effects and begin to develop general principles to guide implementation of special regulations for protecting and rebuilding fish populations.

Finally, it is important to recognize that the use of special angling regulations to limit harvest is simply one part of an integrated fishery management program. In areas where aquatic habitats have been severely degraded by land management activities, or biological assemblages have been disrupted by the introduction of nonnative species, other management actions may be necessary. Even in pristine areas, low productivity may limit the effectiveness of special regulations. These few examples underscore the necessity of developing realistic management goals and objectives that are concordant with the other components of the aquatic systems under consideration. It is apparent, however, many native fishes are highly susceptible to capture by anglers, and although angler harvest may not be the direct cause of population decline, it is often wise to incorporate special regulations in any integrated effort to maintain or rebuild populations of native fishes.

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Stocking Trout of Wild Parentage to Restore Wild Populations: An Evaluation of Wisconsin's Wild Trout Stocking Program

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ABSTRACT—The Wisconsin Department of Natural Resources (WDNR) manages trout streams using a combination of stream habitat protection and improvement, fishing regulations, and stocking of hatchery-reared trout. The WDNR initiated a wild trout stocking program in 1995 to improve the quality of hatchery-reared brook and brown trout by raising offspring of wild parentage. The goals of the wild trout stocking program are to increase the survival and longevity of trout stocked in streams and to ultimately develop self-sustaining populations of wild trout. It is thought that hatchery trout of wild parentage maintain the genetic diversity and better embody the characteristics found in wild populations and may therefore improve restoration success. I collectively analyzed evaluations of wild trout stocking across Wisconsin to determine whether program goals were being fulfilled and to identify any research gaps. Preliminary analyses indicated survival rates 2-4 times greater for stocked trout of wild versus domestic parentage, and some increases in natural reproduction have been observed. Habitat, however, may be limiting the restoration of self-sustaining populations in some streams. Future research will address habitat limitations to survival and reproduction of stocked wild trout and the long-term viability of source populations for the wild trout stocking program.

Introduction

The Wisconsin Department of Natural Resources (WDNR) manages trout fisheries in 10,371 miles of classified trout streams using a combination of stream habitat protection and improvement, fishing regulations, and stocking of hatchery-reared trout. About 40% of the trout stream mileage (Class I) support natural reproduction sufficient for the maintenance of wild trout populations, but populations in 45% (Class II) require supplementation by stocking and populations in 15% (Class III) are wholly dependent on stocking. Through WDNR management efforts, miles of Class I and II streams have increased and miles of Class III streams have decreased in recent years. Trout habitat has been improved by land conservation measures, which have reduced siltation from erosion and improved groundwater flow (Gebert and Krug 1996), and by the restoration of damaged stream habitat (Hunt 1993). Hunt (1988) and Avery (2004) documented a half century (1953-2000) of evaluations of trout stream habitat improvement projects, which have been supported by annual trout stamp sales since 1978.

Trout stocking has a long history in Wisconsin dating back to the 19^{th} century. Significant changes, however, have occurred in recent years. The WDNR initiated a wild trout stocking program in 1995 in contrast to its long-standing domestic trout stocking program. The idea of stocking trout of wild parentage has been around at least since the 1960's but rearing wild trout in a hatchery was impractical at that time (Flick and Webster 1964; Mason et al.

1967). Domestic strains of hatchery-reared trout often failed to sustain a fishery beyond the early season and failed to contribute to natural reproduction in Wisconsin streams (Avery et al. 2001). Poor survival of domestic trout stocked in Wisconsin streams was observed in the early 1990's during a time of severe drought and harvest prohibition (Avery et al. 2001). This prompted interest in developing a wild trout stocking program to improve the quality of hatchery-reared trout and their potential for sustaining stream fisheries.

Wisconsin's wild trout stocking program involves taking wild brook trout *Salvelinus fontinalis* and brown trout *Salmo trutta* from streams, spawning them at a fish hatchery, and later returning the spawned trout to the streams from which they came. Offspring of the wild parents are raised at reduced densities in a hatchery and stocked elsewhere in the state as spring or fall (autumn) fingerlings or spring yearlings. It is thought that these trout of wild parentage better maintain the genetic diversity found in wild populations and embody the characteristics of wild trout as compared to offspring from domestic broodstock. To help maintain "wildness" in the trout, human contact is minimized by partially shading tanks at the hatchery and feeding trout continuously throughout the day using an automatic feeder. The 2003-2004 wild brook trout stocking quota included 95,500 spring fingerlings and 7,600 fall fingerlings; the wild brown trout stocking quota included 40,700 spring fingerlings, 28,250 fall fingerlings, and 6,980 spring yearlings. Wild brown trout were stocked statewide and wild brook trout were only stocked in the southwestern genetic management zone.

The goal of the wild trout stocking program is to use hatchery-reared trout of wild parentage to develop self-sustaining populations of brook trout and brown trout in waters that lack such populations. Specific objectives include increasing the survival and longevity of stocked trout in streams and establishing natural reproduction. This program has become an integral part of trout management in the state. It is generally acknowledged that overall the trout fisheries in Wisconsin today have improved over what they were in the past, and it is thought that the wild trout program has played a key role in this recovery. The goal of this study was to evaluate Wisconsin's wild trout stocking program by collectively analyzing evaluations of wild trout stocking across the state to determine whether program goals and objectives were being fulfilled.

Methods

I distributed a memorandum to WDNR fisheries mangers and biologists requesting them to provide any available data, analyses, and reports pertaining to the evaluation of wild brook and brown trout stocking. I also requested that they include similar information that may be available concerning the evaluation of domestic brook and brown trout stocking prior to the start of the wild trout stocking program, particularly for streams that later received wild trout. I received unpublished data and reports on wild brown trout stocking in 15 streams and wild brook trout stocking in 1 stream. Included is one published report on wild and domestic brown trout stocking in two streams, the Waupaca River and the West Fork Kickapoo River (Avery et al. 2001).

I evaluated the data, analyses, and reports to determine if stocked wild trout had higher survival and longevity rates compared to domestic trout and to determine if natural reproduction was occurring as a result of wild trout stocking efforts. Survival was estimated by comparing densities of trout over time (number per mile); densities were estimated using a single marking run and a single recapture run unless noted otherwise. I reported survival rates as apparent survival rates because comparisons of densities more accurately reflected losses, which could be attributable to mortality or movement. The initial density used in apparent survival calculations was the initial stocking density. However, in some reanalyses of the data as noted in the results section, I used the estimated density after stocking had occurred as the initial density.

Results

There were sufficient data to evaluate survival, longevity, or reproductive success for stocked wild versus domestic trout in 9 of 15 streams stocked with brown trout (Table 1).

Table 1. Summary of wild brown trout stocking results in terms of survival, longevity, and reproductive success compared to domestic brown trout stocking. If there were insufficient data or results were inconclusive for a stream then the column was left blank.

Stream name	Stocked wild trout survival greater than domestic trout survival?	Stocked wild trout longevity greater than domestic trout longevity?	Successful reproduction from stocked wild trout?
Hunting River		Yes	Yes
McCaslin Brook	No	No	No
North Branch Oconto River	No	No	No
Onion River			Yes
Peshtigo River	Yes	Yes	
Rocky Run	Yes		
Rowan Creek	Yes		
Waupaca River	Yes		
West Fork Kickapoo River	Yes		

Apparent Survival

There was evidence that apparent survival rates of stocked wild brown trout exceeded apparent survival rates of domestic brown trout in five streams. Avery et al. (2001) evaluated the performance of stocked wild, domestic, and optimum domestic brown trout in the Waupaca and West Fork Kickapoo rivers. Optimum domestic trout were reared under conditions similar to those for hatchery wild trout: little human contact and at about half the density of standard hatchery protocol. Wild, optimum domestic and domestic fall fingerlings (age 0) brown trout were stocked in the Waupaca River in fall 1993 and 1994. Apparent survival ϕ was about 2–4 times greater for wild ($\phi = 0.22$–0.34) versus optimum domestic ($\phi = 0.06$–0.13) or domestic trout ($\phi = 0.10$) after one year and about 4–8 times greater for wild ($\phi = 0.08$) versus optimum domestic ($\phi = 0.02$) or domestic trout ($\phi = 0.01$) after two years. Wild, optimum domestic, and domestic spring yearling (age 1) brown trout were stocked in the West Fork Kickapoo River in spring 1994 and 1995. Densities in electrofishing stations increased for wild trout (indicating recruitment) and decreased for optimum domestic and domestic trout between the spring stocking and fall. I recalculated apparent survival rates using density in the fall after the spring stocking as the initial density and found that apparent survival from age 1 to age 2 was about 5 times greater for wild ($\phi = 0.53$) versus optimum domestic ($\phi = 0.10$) or domestic trout ($\phi = 0.11$). A similar calculation for the Waupaca River showed that apparent survival from age 1 to age 2 was about 1.4–2.3 times greater for wild (ϕ = 0.23) versus optimum domestic (ϕ = 0.17) or domestic trout (ϕ = 0.10). Apparent survival in the West Fork Kickapoo River from age 1 to age 2.5 (fall 1994 to spring 1996) was about 5-31 times greater for wild (ϕ = 0.31) versus optimum domestic (ϕ = 0.06) or domestic trout (ϕ = 0.01).

Wild brown trout were stocked as spring fingerlings in six small Columbia County streams in southwestern Wisconsin. Apparent survival from age 0 (fall) to age 1 (fall) was about 2 times greater for stocked wild versus domestic brown trout (Tim Larson, WDNR, unpublished data). Average apparent survival was about 0.19 for stocked wild trout (2001-2003) versus less than 0.10 for domestic trout (1984-1987) in Rocky Run and Rowan Creek. Average apparent survival for stocked wild trout in four other streams was about 0.22 (Dell, Honey, Jennings, and Leech creeks, 2001-2003), but there were no data on apparent survival rates for domestic trout in these streams for comparison.

Apparent survival of stocked wild brown trout in the Peshtigo River was greater than that of domestic brown trout as was evident by the densities of age 2 and age 3 and older trout (David L. Brum, WDNR, unpublished data). There was no evidence of survival of domestic trout to age 3 and older in 1988 and 1997, even though many of those trout were stocked as spring yearlings. The number of domestic brown trout per mile based on single-pass electrofishing samples was 35 (age 1) and 7 (age 2) trout in 1988 and 26 (age 1) and 2 (age 2) trout in 1997. There was evidence of survival to age 3 and older for stocked wild brown trout in 2001-2003 (wild trout stocking began in 1998), with densities higher than densities of age-2 domestic trout. Average densities of stocked wild brown trout for 1998-2003 were 149 (age 0), 104 (age 1), 16 (age 2), and 9 (age 3 and older). A comparison of densities of stocked wild brown trout showed apparent survival rates of 0.11-0.15 from age 1 to age 2.

Stocked wild brown trout did not survive better than domestic brown trout in McCaslin Brook and the North Branch Oconto River (Lee Meyers, WDNR, unpublished data). McCaslin Brook is a tributary of the North Branch Oconto River. Wild brown trout were first stocked in the North Branch Oconto River in 1996 and in McCaslin Brook in 1997. Historic population estimates showed brown trout densities of 139 per mile in 1973, 385 per mile in 1988, and 74 per mile in 1996 in McCaslin Brook. Brook trout were also present (10 per mile in 1973 and 55 per mile in 1988). After wild brown trout were stocked in 1997, densities increased to 545 per mile in 1997 and 1,300 per mile in 1998. However, warm water temperatures of 26.7 °C and higher were recorded on three occasions in July 1999, and the brown trout density had decreased to 218 per mile by August 1999. The brook trout density, however, had not decreased (63 per mile in 1999). Similar population estimates were not available for the North Branch Oconto River, but a creel survey confirmed that stocked wild brown trout did not provide for a significant fishery. Concerns that stocked wild brown trout were not surviving prompted a return to stocking domestic yearling brown trout in 2000. A creel survey in 2000 found that the trout harvest included 71% domestic brown trout, 25% wild brook trout, and 4% wild brown trout (stocked or naturally occurring; all from the North Branch Oconto River).

Apparent survival could not be estimated for brown trout in the Hunting River, Onion River, and Pine River and brook trout in the West Branch Eau Claire River because stocked wild naturally produced and domestic fish or age classes could not be separated in the data. Therefore, these evaluations were inconclusive on the question of whether stocked wild versus domestic trout survive better in these streams.

Longevity

Longevity of stocked wild brown trout was not greater than longevity of domestic brown trout in McCaslin Brook and the North Branch Oconto River because survival of stocked wild brown trout was poor as outlined above. There was, however, evidence of increased longevity for stocked wild brown trout in the Hunting and Peshtigo rivers. The 1,000 wild brown trout stocked in the Hunting River in 1996 at age 0 had a year-specific fin clip and two of these fish were recaptured in 2003 at age 7 (David A. Seibel, WDNR, unpublished data). In the Peshtigo River there was no evidence of survival of domestic brown trout past age 2 in 1988 and 1997, but there was evidence of stocked wild brown trout surviving to age 3 and older (2001-2003 with stocking beginning in 1998). Longevity of stocked trout could not be evaluated for any of the other streams because age classes could not be separated in the data or the length of the study was too short.

Reproduction

Evidence of reproduction consistent with wild trout stocking was observed in the Hunting and Onion rivers. Young-of-year brown and brook trout were observed from 1999 to 2003 in the Hunting River, indicating that natural reproduction had occurred. Population estimates also suggested that natural reproduction had occurred (Table 2). The density of stocked wild brown trout (last stocked in 2001) generally decreased from 1998 to 2003, whereas the density of stocked domestic (last stocked in 1999) and naturally produced brown trout, which were confounded in the data, increased from 1998 to 2000. Domestic and naturally-produced brown trout decreased thereafter, but densities were 5 to 9 times greater than stocked wild brown trout. The increase in density of domestic and naturally produced brown trout in 2000 and sustained higher densities thereafter were consistent with reproduction that may have resulted from stocked wild brown trout. Reproduction from domestic trout cannot, however, be ruled out.

Table 2. Number of stocked wild and domestic brown trout by age and density (number per mile (No./mi)) of stocked wild brown trout and combined stocked domestic and naturally produced brown trout (age 1 and older).

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003
				Number of stocked wild brown trout					
0		1,000	2,000	1,000	500	2,000	1,000		
No./mi				**482**	**125**	**134**	**83**	**32**	**17**
				Number of stocked domestic brown trout[1]					
0		1,000							
1	1,000		1,000	1,000	1,000				
2				644					
No./mi		**67**		**414**	**467**	**546**	**439**	**201**	**159**

[1] Density (No./mi) is combined stocked domestic and naturally-produced brown trout

Evidence of reproduction in the Onion River was observed in an increase in the number of unclipped brown trout over time (Table 3) (John E. Nelson, WDNR, unpublished data). The Onion River was historically stocked with domestic brown trout. Spring yearling domestic brown trout were stocked in 1995 and were last stocked in 1997 along with some age-2 trout. The stocking of wild brown trout started in 1997 with the transplant of age-1 wild brown trout from two streams in the Coon Valley watershed. These fish received an adipose clip. Fall fingerling wild brown trout were also stocked in 1997, but these did not receive an adipose clip. No fish were stocked in 1998, spring yearling wild brown trout were stocked in 1999 (adipose clip), and fall fingerling wild brown trout were stocked in 2000 (adipose clip). There have been no subsequent stockings in the Onion River watershed. The number of unclipped trout per mile (single-pass electrofishing counts) increased from 100 in 1999 to 281 in 2001. This increase in unclipped trout was consistent with the potential spawning of wild trout stocked in 1997 (adult transfers and fall fingerlings). Evidence of reproduction was found in the unclipped trout observed in 1999-2001, many of which were less then four inches in total length.

Table 3. Number of unclipped and clipped brown trout per mile from 1997 to 2001 in the Onion River.

Year	Number of unclipped trout per mile	Number of clipped trout per mile
1997	89	
1998	161	80
1999	100	110
2000	180	31
2001	281	56

Reproduction of stocked wild brown trout was not observed in McCaslin Brook and the North Branch Oconto River because survival of stocked wild brown trout was poor as outlined above. Reproductive success of stocked trout could not be evaluated for any of the other streams because stocked fingerlings were unmarked and could not be distinguished from naturally-produced trout or it was not an objective of the study (e.g., Avery et al. 2001).

Discussion

Early investigations of the performance of stocked wild trout versus domestic trout showed higher survival rates for stocked wild trout. Flick and Webster (1964) investigated differences in survival during the first year after stocking for spring and fall fingerling brook trout of domestic versus wild parentage. Oversummer survival was greater for wild (0.65-0.76) versus domestic (0.43-0.53) brook trout fingerlings; overwinter survival did not differ but was likely confounded with the larger size advantage of domestic trout. Mason et al. (1967) investigated survival of domestic, wild, and domestic/wild hybrid brook trout stocked in five central Wisconsin streams as fall fingerlings. Domestic brook trout had a higher overwinter survival rate (0.38) than stocked wild brook trout (0.25); however, after one complete year, stocked wild brook trout had a higher survival rate (0.10) than domestic brook trout (0.007).

The study by Avery et al. (2001) on wild trout stocking in the Waupaca and West Fork Kickapoo rivers was initiated to further quantify the field performance of stocked wild versus domestic trout specifically in Wisconsin streams. Early results in this study were positive in favor of wild trout stocking, and the wild trout stocking program was spread to other streams throughout the state. The original intent of wild trout stocking was for it to be a temporary management action towards establishing self-sustaining populations. This goal may have been achieved in the Hunting River. Although survival rates could not be determined from the data for stocked wild versus domestic brown trout in the Hunting River, there was evidence of longevity in the observation of age-7 stocked wild trout and there was evidence of reproduction. No stocking will occur in the Hunting River from 2002 to 2006, whereupon the need to resume stocking will be evaluated. The Onion River has also had successful reproduction since being stocked with wild brown trout. There has been no stocking in the Onion River since 2000; future evaluations of the trout population will determine the ultimate success of wild trout stocking in the Onion River.

Apparent survival rates of stocked wild trout have exceeded apparent survival rates of domestic trout as long as habitat was not a limiting factor. Apparent survival rates were generally at least two times greater for stocked wild versus domestic brown trout from age 0 to age 1 or from age 1 to age 2. Survival rates to older ages were even greater for stocked wild trout and have resulted in increased longevity. Stream habitat may, however, determine just how much greater the survival of stocked wild trout versus domestic trout may be. For example, the apparent survival from age 1 to age 2 for stocked wild versus domestic brown trout was about 5 times greater in the West Fork Kickapoo River as compared to about 2 times greater in the Waupaca River. The West Fork Kickapoo River is a highly fertile river compared to the Waupaca River and it has been suggested that the higher growth rates observed in the West Fork Kickapoo River were responsible for the higher survival rates (Avery et al. 2001).

Habitat was a limiting factor in McCaslin Brook and the North Branch Oconto River, where summer maximum water temperature exceeded 26 °C on several occasions in 1999. The wild trout stocking observations from these streams underscores the importance of stream habitat to supporting wild trout populations. A wild trout stocking program cannot substitute for quality trout habitat. Wisconsin's active stream habitat restoration program, which has a dedicated funding source via the sale of trout stamps, and Wisconsin's land conservation measures have helped to improve trout stream conditions such that the wild trout stocking program serves as a viable management tool.

Apparent survival of stocked trout can be improved by using trout of wild parentage, but successful reproduction may not necessarily follow. Many streams may support juvenile and adult trout but fail to provide adequate spawning habitat. Here again, habitat limitations need to be surpassed before the goal of establishing self-sustaining trout populations can be realized. However, the question is raised as to whether wild trout stocking may be preferred over domestic trout stocking in situations where successful reproduction may not be realized. If stocked wild trout can survive from year to year in streams that lack spawning areas, then wild trout stocking will work for supporting trout fisheries in those streams. Fisheries managers will have to determine whether the costs of a wild versus domestic trout stocking program are justified for such streams and their fisheries.

Brook trout are the only stream salmonid native to Wisconsin. Brown trout have been successfully introduced throughout the state and coexist with brook trout in many streams. However, brown trout have also displaced brook trout in many streams. Successful wild brown trout stocking may therefore be an impediment to protecting or restoring brook trout populations. Mixed brook trout and brown trout populations were present in the Pine River, McCaslin Brook, and the North Branch Oconto River. Brook trout were not stocked in McCaslin Brook and the North Branch Oconto River, but they were self-sustaining and constituted about 25% of the trout fishery. Interestingly, whereas high summer water temperatures limited stocked wild brown trout in 1999, wild brook trout persisted, possibly by finding suitable refuge. Future wild brown trout stocking will be avoided in McCaslin Brook, the North Branch Oconto, and other similar streams with brook trout populations in northeastern Wisconsin (Lee S. Meyers, WDNR, personal communication).

The potential for brook trout restoration should also be a consideration when deciding to stock wild brown trout in streams without self-sustaining trout populations. David M. Vetrano (WDNR, personal communication) has commented that wild brown trout populations have been established in westcentral Wisconsin streams that at the time would not have supported brook trout. Subsequent improvements in land use have improved groundwater flow such that those streams would now have been suitable for brook trout. The presence of brown trout is now an obstacle to brook trout restoration.

When developing a wild trout stocking program, consideration should be given to the genetics of the source populations. Stocking trout derived from wild parents helps to avoid overwhelming native genetic diversity and to prevent the loss of genetic diversity. Fields and Philipp (1998) documented levels of genetic diversity consistent with distinct stocks of brook trout. Therefore, different source populations for brook trout are needed for different parts of the state. Brook trout from the Ash Creek source population are currently stocked in the southwestern genetic management zone. Brook trout source populations for the northern part of the state were recently identified in Dority Creek and the South Fork of the Hay River (Heath M. Benike, WDNR, personal communication). Other source populations have been used in the early stages of the wild trout stocking program but have been discontinued from use due to disease issues. Genetic analyses of Wisconsin brown trout populations have determined that wild brown trout from the southwestern Timber Coulee Creek source population can be stocked statewide. However, stocked wild brown trout from northeast source populations (West Branch White River and Brule River) were found to have survival rates about four times greater than those from the southwestern population when stocked in the Waupaca River in northeastern Wisconsin (Al Niebur, WDNR, unpublished data).

Future studies of wild trout stocking are needed to better understand how habitat conditions determine the improvement in survival for wild stocked trout versus domestic stocked trout and therefore in which types of streams better success can be expected. Large annual variation in salmonid survival is common (Needham et al. 1945; Hunt 1969; Seelbach 1993; Mitro and Zale 2002); therefore, long-term studies may be necessary. Study designs should ensure that stocked wild trout and domestic trout can be distinguished from each other and from naturally-produced trout in the study stream, and if possible, among cohorts. Batch tags such as visible implants of fluorescent elastomer (Northwest Marine Technology, Inc.) used in different colors and locations on the trout are suitable for this purpose. Clipping fins can also be used to distinguish batches of fish, but batch codes are obviously somewhat limited. Consistent use of the same electrofishing stations from year to year will ensure that valid comparisons of densities can be made among years.

I am currently initiating a study to investigate the long-term viability of wild brook trout and brown trout populations as source populations for Wisconsin's wild trout stocking program. Wild brook trout have been obtained from Ash Creek since 1999 and wild brown trout have been obtained from Timber Coulee Creek since 1995. Little is known about the trout population in either stream. Each stream supports a wild trout population protected from harvest by a no-kill regulation. A sufficient number of trout have been captured to meet yearly egg quotas (about 198,000 brook trout eggs and 114,000 brown trout eggs in 2002) for the wild trout stocking program. However, we do not know what effect the annual removal of reproductive output from each stream has had on the long-term viability of each source population. Dr. Brian Sloss (Wisconsin Cooperative Fisheries Research Unit, University of Wisconsin-Stevens Point) is initiating a companion study to examine the potential and realized genetic impacts of wild broodstock selection in Wisconsin's wild trout stocking program. Together, these studies will result in a quantitative understanding of the effects of broodstock selection and egg collection on the source populations for the wild trout stocking program and will aid management decisions such that the viability of the source populations for the wild trout stocking program can be maintained.

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Quirk Creek Brook Trout Suppression Project

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ABSTRACT— A brook trout *Salvelinus fontinalis* suppression project utilizing anglers was initiated in 1998 to facilitate recovery of native westslope cutthroat trout *Oncorhynchus clarkii lewisi* and bull trout *Salvelinus confluentus* populations in Quirk Creek, Alberta. Participating anglers were required to pass a fish identification test, harvest all brook trout caught and release all other fish. Only 15 of the 7955 fish harvested were not brook trout. Although brook trout catch rates remained relatively high (1.0-2.5 fish/angler-h) and brook trout dominated the angler catch (54-73%), brook trout density has declined since 2000 while the abundance of juvenile cutthroat trout increased in 2003, resulting in a decline in the proportion of brook trout in the electrofishing catch.

Introduction

Brook trout *Salvelinus fontinalis*, although not native to Alberta, are present in many montane and foothills waters as a result of extensive stocking. In southern Alberta, brook trout populations have generally increased while native westslope cutthroat trout *Oncorhynchus clarkii lewisi* and bull trout *Salvelinus confluentus* populations have declined. Brook trout life history attributes (early spawning age, reduced longevity and low catchability) have resulted in the replacement of native bull trout and cutthroat trout fisheries with fisheries for smaller, less-catchable, non-native brook trout.

Management programs to reduce or eliminate non-native trout populations often involve pesticides and/or electrofishing (Moore et al 1983; Buktenika 1997; Kulp and Moore 2000). However, Larson et al. (1986) suggested that experimental angling programs might offer a cost-effective, alternative method for reducing densities of non-native trout. Although Larson's study only ran nine weeks, it appeared that anglers reduced the non-native trout population by about 10%.

Since pesticides are only suitable in certain situations and there are insufficient resources to attempt removal of non-native trout by electrofishing in all streams where native trout populations appear to be threatened, the option of selectively removing non-native trout by angling provides an appealing alternative. Our objective in this study was to determine whether angling could be an effective method for reducing densities of non-native brook trout in Quirk Creek, Alberta, to facilitate recovery of the native trout population.

Study Area

Quirk Creek is located 50 km southwest of Calgary in a designated off-highway vehicle (OHV) area. A good dirt road comes within 0.5 km of the creek for most of its length. Anglers participating in this project were allowed direct vehicle access to this road by fording the Elbow River, but only on supervised outings under the direction of the volunteer coordinator. A locked gate prevents anglers on unsupervised outings from crossing the Elbow River by vehicle.

Most of Quirk Creek meanders through a large wet meadow dominated by grasses and low (< 1 m) shrubs. Although cattle and OHVs have degraded streambanks in a few areas, most of the streambanks are undamaged and provide good fish habitat, consisting of deeply undercut banks with overhanging terrestrial vegetation. The lower 2 km of creek flows through a narrow valley before joining the Elbow River at an elevation of 1530 m. There are no permanent barriers on the creek, although beaver dams up to 1.5 m high are scattered along the creek.

Brook trout colonized Quirk Creek subsequent to their introduction to the Elbow River watershed in 1940. Although native cutthroat trout and bull trout were the only fish captured in Quirk Creek in 1948, brook trout had colonized the lower 3 km of the creek by 1978, comprising 35% of the fish population, and spread throughout the entire creek by 1995, comprising 92% of the fish population. These changes occurred despite the implementation of reduced bag limits and minimum size limits designed to provide more protection for native trout (Stelfox et al. 2001a). Since 1998, harvest of all fish has been prohibited in Quirk Creek, except by anglers participating in the project.

A bridge divides Quirk Creek into upper and lower reaches, with the lower reach serving as a control during the first two years of the project. Surface areas of the upper and lower reaches were estimated to be 1.65 and 1.8 ha, respectively, by extrapolating the mean widths of the creek (3.3 and 3.6 m) within the respective electrofishing sites to the approximate lengths of each reach (5 km).

Methods

Fish Identification Education

To participate in the project, all anglers had to pass a fish identification test on an annual basis to demonstrate their ability to identify the three fish species found in Quirk Creek. If a person failed the test on their first attempt, they were given a dichotomous key with pictures of the key-identifying features (a list of key-identifying features in 1998) and were permitted to take the test a second time with the key (list) in front of them. For a more detailed discussion of the fish identification test, refer to Stelfox et al. (2001b).

Angling

Participating anglers were required to harvest all brook trout caught and were initially only allowed to harvest brook trout from the upper reach of Quirk Creek on supervised outings. However, beginning in 2000, anglers also harvested fish from the lower reach to assess brook trout immigration and, starting in 2001, some of the more skilled anglers harvested fish on unsupervised outings. Anglers only fished from June to October, could not use bait, and were required to release all bull trout and cutthroat trout after recording the length of each fish in 5-cm size classes.

All harvested brook trout were delivered whole to the volunteer coordinator at the end of each outing for measuring (fork length, nearest 1 mm) and weighing (nearest 1 g) and then returned to the angler. Anglers on unsupervised outings recorded fork lengths (nearest 1 mm) of all brook trout caught and filled in creel cards.

Electrofishing

Removal-method estimates of the fish population in Quirk Creek were obtained by electrofishing sections of both reaches between mid-August and early September (Paul 2004). With the exception of 1987, when the mark-recapture method was used, attempts were made to capture all fish, including age-0 brook trout (< 100 mm) and cutthroat trout (< 70 mm).

To assess immigration of large (> 150 mm) brook trout into the upper reach from the lower reach, the upper 2.5 km of the lower reach was electrofished on 6 May 2000 and 2 June 2001 to capture, mark, and release 750 and 92 large (> 150 mm) brook trout, respectively. All bull trout and cutthroat trout, and marked brook trout, were measured before release. A mark-recapture estimate of the population of large brook trout present in the lower reach on 6 May 2000 was obtained by applying the Petersen estimate, corrected for size, to the marked brook trout recaptured by anglers in the lower reach in 2000.

Ageing and Maturity

Fish were aged by otoliths collected from a subsample of the fish captured by electrofishing in 1987, 1995 and 2000, and from any cutthroat trout and bull trout mortalities encountered during the study (Stelfox et. al. 2001a). Maturity was determined for all fish from which otoliths were collected.

Results

Fish Identification Education

Of 376 people who had never before taken the test, 52% failed on their first attempt. However, of those who failed their first attempt, 76% passed their second attempt, after shown the key-identifying features for each species. Mean scores on the first and second attempt were 90% and 97%, respectively. Most (≈ 75%) of the people who took the test were experienced anglers, reporting that they had fished for more than 10 years.

During the 1998–2000 periods, 54 individual anglers took the test in more than one year. Although 33% of these anglers failed the test on their very first attempt, the failure rate in subsequent years on the first attempt was only 9% and none failed their second attempt.

Angling

Average annual catch rate for brook trout in the upper reach remained high (2.2–2.5 fish/h) during the first three years of the study, but declined to 1.0 fish/h by 2002 (Table 1). In contrast, catch rates for brook trout in the lower reach changed little, ranging from 1.3 to 1.8 fish/h. Aggregate catch rates in both reaches were generally about 1.0 fish/h higher than for brook trout alone (Table 1).

Fishing effort peaked at 397 h/ha in the upper reach in 1999 and 549 h/ha in the lower reach in 2000 (Figure 1). Since then, fishing effort has been consistently higher in the lower reach, but has declined substantially in both reaches.

Table 1. Angling data summary for Quirk Creek, 1998-2003. All brook trout were harvested.

Year	Number of anglers	Number of fish caught: Bull trout	Cutthroat trout	Brook trout	Total	Number of hours fished	Catch rate: (fish/h)	(brook trout/h)	Percentage of catch: Bull trout	Cutthroat trout	Brook trout
					Upper reach						
1998	97	63	349	1076	1488	436.0	3.4	2.5	4.2	23.5	72.3
1999	146	161	735	1412	2308	655.5	3.5	2.2	7.0	31.8	61.2
2000	111	68	522	1128	1718	477.3	3.6	2.4	4.0	30.4	65.7
2001	70	19	276	511	806	271.3	3.0	1.9	2.4	34.2	63.4
2002	26	1	71	83	155	82.5	1.9	1.0	0.6	45.8	53.5
2003	15	1	45	57	103	55.5	1.9	1.0	1.0	43.7	55.3
Upper Total	**465**	**313**	**1998**	**4267**	**6578**	**1978.0**	**3.3**	**2.2**	**4.8**	**30.4**	**64.9**
					Lower reach						
2000	204	115	807	1644	2566	988.8	2.6	1.7	4.5	31.4	64.1
2001	142	39	544	1101	1684	619.0	2.7	1.8	2.3	32.3	65.4
2002	119	12	287	555	854	432.5	2.0	1.3	1.4	33.6	65.0
2003	56	12	211	373	596	206.0	2.9	1.8	2.0	35.4	62.6
Lower total	**521**	**178**	**1849**	**3673**	**5700**	**2246.3**	**2.5**	**1.6**	**3.1**	**32.4**	**64.4**
Grand total	**986**	**491**	**3847**	**7940**	**12278**	**4224.3**	**2.9**	**1.9**	**4.0**	**31.3**	**64.7**

The number of hours fished on supervised outings has declined substantially since initiation of unsupervised outings in 2001 (Figure 2). This decline, in conjunction with the higher catch rates of anglers on unsupervised outings (Figure 3), has resulted in an increase in the relative importance of unsupervised outings for brook trout harvest (Figure 4). By 2003, about 2/3 of all brook trout harvested were taken by anglers on unsupervised outings.

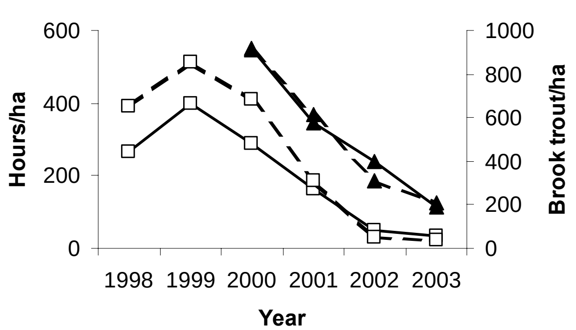

Figure 1. Fishing effort (solid lines) and brook trout harvest rates (dashed lines) in the upper (squares) and lower (triangles) reaches of Quirk Creek.

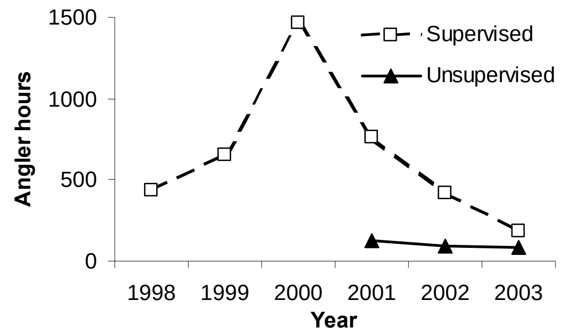

Figure 2. Number of hours fished by anglers on supervised and unsupervised outings on Quirk Creek.

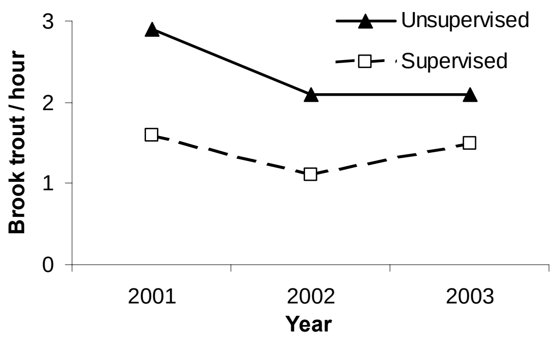

Figure 3. Brook trout catch rates for anglers on supervised and unsupervised outings on Quirk Creek.

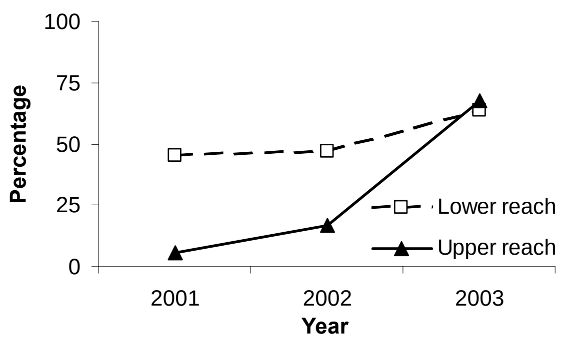

Figure 4. Percentage of brook trout harvested by anglers on unsupervised outings on Quirk Creek.

Harvest rates peaked at 913 brook trout/ha (94.4 kg/ha) in the lower reach in 2000 (Table 2). Since then, harvest rates have declined substantially in both reaches to a low of 35 brook trout/ha in the upper reach in 2003, but have been consistently greater in the lower reach (Figure 1). Mean length of harvested brook trout has changed relatively little over the study, ranging from 173 to 203 mm (Figure 5).

Table 2. Fish population estimates for, and brook trout harvested from, Quirk Creek. With the exception of the mark-recapture estimate in 1987, all population estimates were obtained by the removal method.

		Trout population estimates					Brook trout
					Brook		
Reach	Year	Total	Bull	Cutthroat	All	>150 mm	harvested
				Number per hectare			
Upper	1998	2285	64	264	1958	958	652
	1999	1652	33	167	1452	639	856
	2000	3491	39	715	2736	773	684
	2001						310
	2002	1082	[b]	73	1009	161	50
	2003	1709	79	476	1155	176	35
Lower	1987	778 [a]	50 [a]	508 [a]	219 [a]	114	
	1995	233	[b]	22	211	44	
	1996	431	[b]	28	403	197	
	1997	1456	22	361	1072	475	
	1998	2008	42	269	1697	650	
	1999	1428	[b]	175	1253	525	
	2000	2975	31	444	2500	608	913
	2001						612
	2002	1083	[b]	150	933	428	308
	2003	1217	56	775	386	139	207
				Kilograms per hectare			
Upper	1998	111.5	7.0	13.0	91.5	73.3	56.3
	1999	106.7	2.7	12.1	82.7	59.1	81.9
	2000	114.5	4.2	17.9	92.4	73.0	60.7
	2001						20.9
	2002	26.1	[b]	1.5	24.5	11.2	3.3
	2003	34.8	1.8	4.5	28.5	13.3	3.4
Lower	1987	65.6	4.2	31.7	29.7	11.6	
	1995	6.9	[b]	0.6	6.4	2.5	
	1996	20.6	[b]	2.5	18.1	13.9	
	1997	56.9	0.3	8.6	46.9	37.2	
	1998	88.9	1.9	8.6	78.3	63.1	
	1999	85.0	[b]	15.3	69.7	58.3	
	2000	98.9	3.9	17.2	77.8	60.6	94.4
	2001						41.3
	2002	46.1	[b]	8.3	37.8	27.5	23.4
	2003	25.6	1.4	9.7	14.4	12.2	18.0

[a] *Does not include age-0 fish.*
[b] *Too few bull trout were captured to obtain an estimate.*

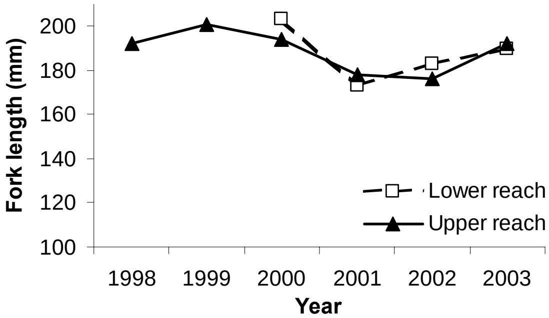

Figure 5. Mean lengths of brook trout harvested by anglers from the upper and lower reaches of Quirk Creek.

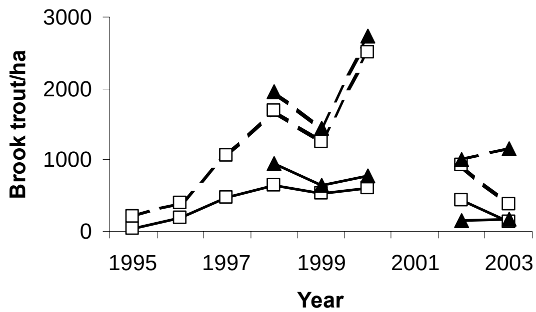

Figure 6. Densities of large (> 150 mm) brook trout (solid lines) and all brook trout (dashed lines) in the upper (triangles) and lower (squares) reaches of Quirk Creek.

Only 4% of the angler-caught brook trout in the upper reach were longer than 250 mm, compared to 32% of the bull trout and 23% of the cutthroat trout. The relationship was similar in the lower reach, where only 6% of the angler-caught brook trout were longer than 250 mm, compared to 22% of the bull trout and 25% of the cutthroat trout.

While the percentage of brook trout in the angler catch in the upper reach declined from 72% in 1998 to 54% in 2002, it remained virtually unchanged (63–65%) in the lower reach (Table 1).

Since inception of the project, anglers have harvested 7955 fish, of which only 15 (0.2%) were not brook trout. All of the misidentified fish were cutthroat trout.

Electrofishing

During the 1987–2003 period, the aggregate trout population in the lower reach declined from 778 fish/ha in 1987 to 233 fish/ha in 1995, and then increased to 2975 fish/ha in 2000 (Table 2).

In 1978, bull trout comprised 54% of the fish population in the uppermost 7 km of the creek and 8% in the lowermost 3 km (Table 3). However, the proportion of bull trout in the fish population of both reaches plummeted to only 1% by 2000. Since 1987, bull trout have not exceeded 80 fish/ha in either reach and numbers of bull trout captured have often been too low to obtain valid population estimates (Table 2).

From 1987 to 1995, cutthroat trout declined from 64% to 5% of the fish population in the lower reach (Table 3), and from 508 to 22 fish/ha, respectively (Table 2). Since then, cutthroat trout have comprised less than 25% of the fish population in the lower reach, until 2003, when they increased to 63% of the fish population and a high of 775 fish/ha. In the upper reach, density of cutthroat trout also increased in 2003, to 476 fish/ha, and the percentage of cutthroat trout in the fish population increased to 25%, up from 6% the previous year, but well below the 46% recorded in 1978 (Table 3). Although the density of cutthroat trout in the lower reach in 2003 was higher than in 1987, the biomass of cutthroat trout (9.7 kg/ha) was only about 1/3 as great as in 1987 (Table 2). Similarly, the biomass of cutthroat trout in the upper reach in 2003 (4.5 kg/ha) was much lower than in most of the previous years.

In 1978, brook trout comprised 35% of the fish population in the lowermost 3 km of the creek, and were not found in any of the four sites electrofished in the uppermost 7 km (Table 3). During the 1995–2002 period, when brook trout comprised 74–92% of the fish population in both reaches, density of large (> 150 mm) brook trout peaked at 958 fish/ha (Table 2). In 2003, the proportion of brook trout in the fish population declined to 32% in the lower reach and 70% in the upper reach — the lowest levels recorded since 1998.

The harvest of 652 and 856 brook trout/ha in the upper reach in 1998 and 1999, respectively, appeared to have very little impact on the density of large (> 150 mm) brook trout in the upper reach relative to the lower reach, which served as a control section until 2000 (Table 2; Figure 6). Subsequent to initiation of brook trout harvest in the lower reach in 2000, the density of large (> 150 mm) brook trout in the lower reach declined by 77% to 139 fish/ha in 2003 — the lowest level recorded since 1998 (Table 2; Figure 6). However, the density of large (> 150 mm) brook trout in the upper reach also declined by 77% to 176 fish/ha, even though fishing effort and brook trout harvest in the upper reach was usually less than half as great as in the lower reach during the 2000–03 period (Table 2; Figure 1).

A comparison of the length-frequency distributions of brook trout caught by angling and electrofishing in 1999 indicates that vulnerability to angling declined below about 210 mm (Figure 7). Anglers were very ineffective at catching brook trout smaller than 150 mm. Brook trout < 150 mm comprised 50–70% of the electrofishing catch, but only 3–11% of the brook trout harvest in the upper reach during the 1998–2000 period. Of 32 brook trout collected for ageing on 26 August 2000, the smallest mature female was 180 mm and none of the mature females were younger than age 3. Age-1, -2, and -3 brook trout averaged 117, 170 and 206 mm, respectively.

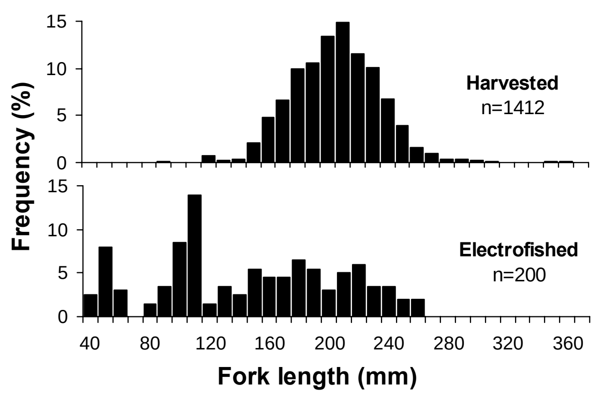

Figure 7. Size distribution of brook trout harvested in 1999 and electrofished on 16 August 1999 from the upper reach of Quirk Creek.

Of the 750 large (> 150 mm) brook trout marked in 2000, anglers subsequently harvested 391 (52%) — 349 (46%) in 2000 and 42 (6%) in 2001. Only eight (2%) of these marked fish were taken from the upper reach — four in 2000 and four in 2001. Of the 92 large brook trout marked in 2001, anglers subsequently harvested 33 (36%) in 2001. None were taken from the upper reach.

Based on recapture in the lower reach of 345 of the 750 brook trout marked on 6 May 2000, and by adjusting for growth over the course of the 2000 fishing season, we estimated that there were 2532 ± 164 (SD) large (> 150 mm) brook trout present in the lower reach on 6 May 2000, or 1407 large brook trout/ha. Using the mean weight (106 g) of the 750 brook trout that were marked on 6 May, the estimated biomass of large brook trout was 149 kg/ha.

By adding each removal-method estimate to the number of brook trout harvested prior to the electrofishing date, we extrapolated the number of large (> 150 mm) brook trout present at the start of each fishing season. Using this approach, we estimated that anglers harvested 45, 68, 57, 27 and 18% of the population of large brook trout in the upper reach in 1998, 1999, 2000, 2002 and 2003, respectively, and 64, 43 and 61% of the population of large brook trout in the lower reach in 2000, 2002 and 2003, respectively.

Table 3. Species composition of the fish population in Quirk Creek.

			Percent composition[a]		
Reach	**Year**	**Sample size**	**Bull trout**	**Cutthroat trout**	**Brook trout**
Upper	1978[b,c]	132	54	46	0
	1998	278	3	12	85
	1999	200	2	11	87
	2000	416	1	21	78
	2002	122	3	6	91
	2003	178	5	25	70
Lower	1978[b,d]	208	8	57	35
	1987	187	7	64	29
	1995	79	3	5	92
	1996	72	1	7	92
	1997	255	2	24	74
	1998	280	2	14	84
	1999	195	1	13	86
	2000	355	1	16	83
	2002	186	2	12	86
	2003	205	5	63	32

[a] *Determined from the number of fish in the electrofishing catch.*
[b] *Calculated from data in Volume II (Appendices) of Tripp et al. (1979).*
[c] *The section electrofished in 1978 was the uppermost 7 km of the creek.*
[d] *The section electrofished in 1978 was the lowermost 3 km of the creek.*

Discussion

The fish identification key proved to be effective in teaching anglers how to identify fish, considering that only 15 of the 7955 fish harvested by anglers participating in this project were not brook trout. Additionally, long-term retention of the key-identifying features by anglers was encouraging, given that only 9% of the anglers failed the test on their first attempt in subsequent years, even though the failure rate on their very first attempt was 33%.

Angler harvest of more than 650 brook trout/ha (55 kg/ha) from the upper reach in 1998 and 1999 appeared to have little impact on brook trout catch rates, the mean length of brook trout caught or the density of large (> 150 mm) brook trout in the upper reach relative to the lower reach. In contrast, average annual angler harvest of 25 kg/ha of trout over a 10-year period from Sagehen Creek, California, which equated to 66% of the average standing crop of trout, had a relatively large effect, given that the average total number and weight of all trout nearly doubled and the number of trout ≥ 200 mm increased 14-fold in a portion of the creek subsequently closed to angling for a six-year period (Gard and Seegrist 1972). Immigration could have reduced the effects of brook trout harvest in the upper reach of Quirk Creek. Gowan and Fausch (1996) found that movement was relatively common, with brook trout usually moving in the upstream direction during and just after runoff, and before spawning. However, in our study, upstream movement did not appear to be sufficient to mask the effects of brook trout harvest in the upper reach, since only 2% of the recaptured brook trout had immigrated into the upper reach.

The apparent lack of impact therefore suggests that angler harvest of 45–68% of large (> 150 mm) brook trout during the 1998–1999 period was insufficient to collapse the population. Although proportions harvested are based on population estimates extrapolated to the start of the fishing season, we feel these extrapolations are reasonable, given the similarity between the independent mark-recapture estimate of large (> 150 mm) brook trout present in the lower reach at the start of the 2000 fishing season (1407 fish/ha) and the extrapolated estimate (1429 fish/ha). However, our extrapolations should still be used with caution, as they do not account for all brook trout mortality or growth that occurred during the approximately two-month angling period prior to the electrofishing dates.

The population estimates suggest that a 1:100-year flood that occurred in June 1995 had a major impact on the fish population. Within five years of the flood, the aggregate population estimate for trout increased numerically by 13-fold and in biomass by 14-fold in the lower reach. Hanson and Waters (1974) documented similar effects following a flood in a Minnesota stream, with a 20-fold increase in brook trout numbers and a 6-fold increase in biomass within four years.

While densities of large (> 150 mm) brook trout have declined in both reaches since 2000, there has been surprisingly little change in the proportion of brook trout in the angler catch, although fishing effort and brook trout harvest has declined substantially in both reaches, especially in the upper reach. However, the electrofishing data suggests that a change may soon occur, given that cutthroat trout densities increased substantially in both reaches due to an influx of age-0 and age-1 cutthroat trout in 2003 (Paul 2004). A 5-fold increase in cutthroat trout density in the lower reach, in conjunction with a decline in brook trout density, resulted in cutthroat trout comprising 63% of the fish population in the lower reach in 2003, up from 12% in 2002. Although there was a larger (6.5-fold) increase in cutthroat trout density in the upper reach, the effect was diminished by a slight increase in brook trout density, resulting in cutthroat trout comprising 25% of the fish population in 2003, up from 6% in 2002.

Whether the increase in juvenile cutthroat trout density in 2003 translates into an increase in catchable-sized cutthroat trout in the future will depend on survival rates. Survival rates apparently varied greatly between the strong year-classes of cutthroat trout in 1996 and 2000 (Stelfox et al. 2001). Although age-0 cutthroat trout were absent from the 1996 electrofishing catch because sampling was conducted two weeks earlier than in 2000 (Paul 2004), survival of the 1996 year-class appears to have been relatively good based on the size distribution (Stelfox et al. 2001) and relatively high densities of cutthroat trout in the following two years. In contrast, survival of the 2000 year-class appears to have been relatively poor, since the density of cutthroat trout in 2002 was lower in both reaches than in any year since 1996.

It is possible that density of large brook trout affects the survival of cutthroat trout. Larson and Moore (1985), in a study of stream populations of brook trout and rainbow trout, found that abundance of age-0 fish of either species was greatly reduced in the presence of 300 or more adults/ha of the other species. A comparable relationship may exist between brook trout and cutthroat trout in Quirk Creek, given that relatively good survival of the 1996 cutthroat trout year-class occurred when there were less than 200 large (> 150 mm) brook trout/ha, whereas relatively poor survival of the 2000 cutthroat trout year-class occurred when there were more than 600 large brook trout/ha.

If density of large brook trout is a major factor in the survival of cutthroat trout fry, then recovery of the cutthroat trout population will be contingent upon preventing the adult brook trout population from increasing to previous high levels. However, this may be difficult to accomplish on the upper reach, where only 18% of the extrapolated population of large (> 150 mm) brook trout were harvested in 2003 compared to 61% in the more accessible lower reach, largely due to a reduction in the number of supervised outings.

Bull trout and cutthroat trout have the potential to provide a better quality fishery in Quirk Creek, based on their larger size and higher catchability. Paul et al. (2003) determined that the catchability of similar-sized bull trout and cutthroat trout was 2.5-fold greater than for brook trout. This higher catchability, however, could prevent a recovery of the native trout population. Paul et al. (2003), using a model developed with data from the Quirk Creek brook trout suppression project, calculated that bull trout and cutthroat trout populations in the upper reach would be extinct within five years at a hooking mortality rate of 10% and an angler effort of 656 angler-hours/year — equivalent to the angler effort in 1999. At hooking mortality rates of 2.5 and 5%, they could still decline.

Although the brook trout population has declined since 2000 and the cutthroat trout population increased in 2003, we cannot yet conclude that angling is an effective means of suppressing non-native trout populations, since the control section was lost when harvest began in the lower reach in 2000 to assess brook trout immigration. However, the project has demonstrated that misidentification of trout is a problem among anglers, but one that can be readily overcome by showing anglers key-identifying features for each trout species. It has also made anglers more aware of the differences between native and non-native trout. Finally, the project has demonstrated that brook trout in Quirk Creek are highly resilient to overexploitation.

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Regaining Public Trust … and Keeping It!

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ABSTRACT—"Ethics are a kind of community instinct in the making." Aldo Leopold, *A Sand County Almanac, 1949.* A definable ethic that contributes to respect, that in turn leads to trust, may well be the "mode of guidance" suggested by Leopold for effectively meeting the social dimension of natural resource decision-making of the future. The authors contend that *fair, open, and honest* are the necessary elements of our management behavior that comprise the core of an ethical approach for conducting agency programs that are increasingly under intense public scrutiny. Simply gaining the elusive public trust is not enough, however, as the public continues to respond to the authenticity exhibited by agencies and their respective professionals, maintaining credibility over time by carrying through on what our agencies say we are going to do, is critical to maintaining public trust. The authors will define how to "make sure actions on the ground match the words on the page." Drawing on their extensive public process experience, the authors contend that if natural resource agency professionals, as a community, embrace the *fair, open,* and *honest* philosophy as the cornerstone of public process, then Leopold's "mode of guidance" will have been defined for the coming century.

Introduction

"An ethic may be regarded as a mode of guidance for meeting ecological situations so new or intricate... that the path of social expediency is not discernible to the average individual... Ethics are a kind of community instinct in the making."

Aldo Leopold, A Sand County Almanac, 1949

Fifty years after Leopold (1949) penned those words, the human component of natural resource science is "so new and intricate" that the path of social expediency is, indeed, "not discernible."

As biologists, foresters, and environmental educators, we have become more than sources of information and data. We've also become professional facilitators embroiled in high stakes, natural resource issues and decisions. We've seen everything from wildly successful public and agency partnerships to dismal failures where litigation seems to be the only solution. We've pondered, time and time again, why some public interactions succeed and others fail; why some proposals move forward and others go to court.

We've analyzed various public involvement models, techniques and processes, such as focus groups, comment periods, public meetings, even charettes. Employing different models or processes doesn't seem to make a significant difference; effective, positive interactions are possible regardless of the model used. We've come to the conclusion that success is not model-dependent; the question then remains as to what factors make or break a public and resource interaction.

Our success is dependent on **processes** that bring together **people** and **information** in a way that promotes, encourages, and supports interactions based on trust. We contend that ethical principles are the framework for establishing trust. These ethics are the driving force for successful collaboration among diverse internal and external publics. They are also the driving force in how information is gathered and shared. In this paper, we advance the premise that fair, open and honest are fundamental principles that comprise the ethics required for successful resource decisions. Fair, open, and honest—the basic components of ethical behavior…that establish credibility... that can lead to trust.

We suggest that, as Leopold stated, a definable ethic is our "mode of guidance" for natural resource decision-making of the future, and second, that a fair, open, and honest ethic is that mode. Further, we contend that this ethic is an action-oriented component, not one in which we simply reflect upon past actions, but one that we use every day to make critical natural resource decisions.

Even today authors continue to support the notion that ethics are key to successful leadership...and that's what we are talking about here: Providing leadership based in ethics. Authors Kouzes and Posner surveyed thousands of businesses and government executives over the course of two decades, asking the question: What values (personal traits or characteristics) do you look for and admire in your leader? They received over 225 different traits and characteristics. After a series of analysis, the list was reduced to 20 characteristics with synonyms for clarification, onto a questionnaire that was then distributed to over seventy-five thousand people around the globe. The results? Consistently over time and across continents, honesty ranks the highest, emerging as the single most important characteristic of a leader. Attributes of integrity and character, were consistently among the top rated. Constituents, whether internal or external want their leaders to be ethical. They expect to be included in processes that recognize and honor the diversity of their contributions. We all want to make progress in our management efforts and decision-making. We can only do that by practicing these fundamental principles in our interactions.

Let's be clear. If your process is not fair, open, and honest, it will not succeed. If you are not ethical how can you sustain credibility and trust among your constituents? It's not that we are purposely or fundamentally unethical. Our science is intense, dynamic, and complex. Practicing ethical behavior means paying close attention to all aspects of what we are doing. Ethics provides the compass that guides our actions through some of our toughest interactions and management decision.

Principle Ethics in Building Trust

Fair

Being fair means several things. For example:

- Providing realistic opportunities for people to participate.

This means providing times and locations that meets the needs of your diverse audiences. We might have to acknowledge that sometimes, the high school playoffs are more important than your public meeting.

- Providing everyone the same information at the same time.
- Providing a safe physical and intellectual environment for the exchange of ideas.

- Making sure the people who are affected by your group's decisions, help make those decisions.

Does everyone have the same opportunity to reflect and respond?

A few self-directed questions are the litmus test for this component of our ethic. How fair is it for biologists to spend two years in obscurity writing a species recovery plan, then say to the public, "You have thirty days to review and comment on this 3-lb document, and, by the way, the clock started ticking last Thursday when the notice was printed in the Federal Register?"

Does everyone get the information and do they get it at the same time?

How fair is it when we provide information to some and not to others? When the others suddenly "find out" what's going on, agency credibility is in jeopardy. Everyone who cares about the issue needs to be involved in the process, not just the supporters or the locals.

For example, one Resource Manager had his predator control program suddenly "blow up" when animal rights advocates found out about it at the very end of the public comment period. When asked why he didn't let national groups know of the process sooner, the answer was, "Well, everyone around here knew about it and thought it was OK."

We need to ask ourselves a fundamental question, "Would we consider this fair if this happened to us?"

Open

The conditions for being open include:

- The process is understandable
- All input is welcome (*really welcome*)
- All pertinent information is shared

The essence of open is the questions:

Are you ***really*** listening?

Supreme Court Judge Stephen Breyer in his confirmation hearing responded to the question, "What is the role of the Supreme Court?" He stated eloquently, "To listen...listening gives dignity to the person being listened to."

In many ways our actions regarding public process have actually trained our constituents to be skeptical of our public involvement strategies. They have become wary of agency "input opportunities" as agencies routinely seek input from the public when a decision has essentially already been made.

Is your process designed to receive information from a diverse audience?

In most cases, natural resource professionals represent public agencies. The public has a fundamental right to provide input on issues that affect them. We need to give them a variety of ways to talk to us-public forums, solicited and unsolicited surveys and assessments, letters, phone calls, whatever is the outreach mode of the moment ...and then we need to *really* listen to their comments and factor them into public decision processes.

Is there a process for dealing with the information?

We often tend to seek validation or acceptance of our plan or strategy, rather than seeking legitimate public input within a truly collaborative process. Margaret Wheatley in her book *Leadership and the New Science* says, “No one is successful if they merely present a plan in finished form to others. It doesn’t matter how brilliant or correct the plan is – it simply doesn’t work to sign on when they haven’t been involved in the plan.”

Honest

Honesty, the heart of integrity and subsequently a key element of personal and agency credibility, is a step along the path to that elusive trust we seek as Agencies. We are responsible for processes that bring people and information together in a way that’s clear.

The conditions for being honest are:

- Letting people know what you can and can not do
- Sharing what kind of information and science we have . . . and how good it is!
- Explaining how information and science will be applied to the problem
- The timeline … some things take awhile, don’t be afraid to say so
- How we will use their input

Fundamental questions we should ask ourselves are:

Is all the information on the table? Is the information understandable? Clear to everyone, not just scientists? (would your neighbor understand it?) Have we shared the alternative and consequences?

At Stake: Credibility

The characteristics of fair, open and honest often overlap as this example illustrates. In one painfully memorable public meeting, the author asked the Assistant Director of the agency, five minutes before the meeting began, "What do we tell them about how their input will be used?" The Assistant Director shrugged and replied, "It doesn't matter… we cut a deal with all the key players at three o'clock yesterday." The public input meeting was held anyway, but had they known the truth, how would those 38 participants have felt about the fairness, openness, and honesty of that public agency and its process? How much dignity was afforded to that audience on that day? More than that - why is it considered acceptable to treat our constituents in that manner?

The examples shared above illustrate a breach of agency credibility. Credibility is at stake when there is a disconnect between our words and actions. It is not enough to espouse to these principles as important: we must give voice to our commitment to them and then set the example with our actions. It is only through consistent words and actions that we are seen as authentic and thus credible, in our management efforts. When our actions do not match our words, our future words become suspect and labeled insincere, ineffective, untrustworthy, or untruthful. When we are consistent in our words and actions people are willing to engage with us in future ventures. They say things like, “I may not agree with the action, but I was treated respectfully”, or “they practice what they preach”, “it was a tough decision, but at least they were fair about it”.

We all know how quickly news about our interactions travels throughout our networks. Margaret Wheatley says, “The capacity of a network to communicate with itself is truly awe inspiring; its transmission capability far surpasses any other mode of communication. But a living network will transmit only *what it decides is meaningful*". We want that "meaningful information" traveling through our agency networks to be that we are fair, open and honest.

If we have no credibility, how can we ever hope to regain the public trust? When our words and actions don't match up… when we are not authentic … people become less willing to engage in any future productive interactions. After all, in the absence of trust everything we do is perceived manipulation.

We contend that our personal and agency credibility, are on the line every time we interact with our constituents. We simply cannot afford to be unethical in our actions.

Trust … A Two-Way Street

You've often heard trust described as a two-way street, something that has to be mutual. The public doesn't trust government these days for a lot of very valid reasons! By the same token, Agencies often don't trust the public ... again, for a lot of very valid reasons.

Air Force General Chuck Horner, General Schwarzkopf's Deputy Commander in the Gulf War, had some interesting comments about one of our mutual "publics" - the media! When asked, "why the military had such a distrust of the media?" He could have been speaking for natural resource agencies as well when he responded:

Fear of the media seems to go with the job description of soldier, sailor, or airman [we can easily include biologist]. Why? God only knows. When you think about it, if you can trust the press and the TV commentator to tell the truth, and I do, then it's not the media we fear but the American people ... a sad commentary on our military mid-set.

Sometimes you...we...all of us do asinine things. If you are doing something stupid, pursuing a poor policy, or wasting taxpayers' dollars, and the press or television paints you in an embarrassing light that is probably a good thing. In the long run, the exposure, no matter how painful, is good for the military and the nation. If, on the other hand, you are getting the job done skillfully, pursuing a noble cause, or managing a military operation with efficiency (how rare that is!), then you have much to gain from media exposure. The American people are quite capable of judging good and bad for themselves. I guess the bottom line is we have little to fear if we trust the judgment of the folks who pay the bills.

Individually or as agencies, we may or may not trust our many and varied publics but we're pretty sure these days it's safe to say, the public doesn't trust us! This mistrust is borne not from an intentional, faulty process, or procedure, but often of actions that have inadvertently been exhibited by agencies and individuals that have preceded us (myself included). If we are perceived by our publics as being unethical we can only dispel that perception by being, from this point on - fair, open and honest.

However, in discussing this topic with colleagues, we often hear the complaint, "why should we be ethical in dealing with the public - they aren't dealing ethically with us!" Our response is simply "who's the professional here? Who should be the first to break the cycle of mistrust ... in order to craft a *new* cycle of trust?"

We need public support more than ever to do our jobs, yet in many cases, the public doesn't trust us as partners and are suspicious of our motives. This suspicion destroys our credibility and erodes our capability to manage our natural resources.

It is clear then, that we need a new approach in natural resource decision-making, one based on mutual trust between the public and public agencies. We advocate a new approach that learns from the past, recognizes the complexities of our current social and biological interactions, and applies a fundamentally ethical approach to managing our natural resources in the future.

Conclusion

We must begin engaging people in a process that is fair, open, and honest. This means

- we include everyone in a proactive process
- we are sincerely listening
- we honor the diversity of ideas
- we engage in truthful dialogue.

Only then, can we can be credible in the eyes of our publics and begin to regain the trust critical to the health and sustainability of our natural resources.

It only takes one person to make a difference. Several years ago, we witnessed one courageous agency individual take a stand when these ethical principles were breached in one small community. The Fish and Wildlife Agency was in the middle of its angling regulation process. There was a proposed change in possession limit that would have severely affected the recreation, and associated business, in a small rural community. The agency had scheduled routine public meetings in the same large towns they always held them in, and advertised in the same publications they used every year.

However, one agency staff member, working in the office serving this community, realized the local folks had not been informed of the proposed regulation change! He took it upon himself to organize an agency public meeting in the community by quickly faxing information about the change and the meeting to community businesses, newspapers, and the radio. He pulled together biologists to plan and conduct a meeting that would provide a forum for sharing information and for hearing community members concerns. As you would imagine the public outcry was swift and loud: “Trying to hide something? Too little, too late? Our input doesn’t matter? You don’t care about us?” Yes, the agency had some explaining to do, but they could (and did). At least this state agency had taken the first step toward handling an issue in an ethical manner!

So what’s next?

We are not expecting you to keep a three-ring binder full of process, procedure, and policy statements in your head to guide your every natural resource decision. What we are saying is that there are simply three fundamental principles that can be tested with some simple questions: Is what we are doing fair, open, and honest? Is what we are doing perceived by others as fair, open, and honest?

These are the questions that will keep you grounded in ethical natural resource management. Will they save us when the issues get hot? Who knows? We only know what happens when we aren’t ethical in our actions. – our credibility, and therefore, our trust is destroyed. Ethics is a choice we make and a trust we keep with those around us.

General Chuck Horner has one other telling point regarding that elusive quality we call trust. He says simply*, "trust takes time, but when you have it you have a wonderful gift."*

This is one gift we can give to ourselves … we should make it so.

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Long-term Results of Mitigating Stream Acidification Using Limestone Sand in St. Mary's River, Virginia

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ABSTRACT—The Virginia Department of Game and Inland Fisheries has been studying the impacts of acid deposition on the biota of the St. Mary's River in Augusta County, Virginia for the past 30 years. During the period preceding 1999, invertebrate diversity decreased by over 50% and the number of fish species dropped from 12 to 4 with only native brook trout still present in significant numbers. From 1994 through 1997, the stream experienced reproductive failure of brook trout for three of the four years. The Department, along with the U.S. Forest Service who administers the area, agreed that the cause of the loss of aquatic life was atmospheric acid deposition and that water quality manipulation was needed to protect the remaining aquatic species as well as restore species that had been extirpated. In a project designed by James Madison University (JMU), limestone sand treatment was proposed for mitigation of the acidity. After much environmental analysis (EA), public debate, and careful consideration, the project was approved and implemented in March of 1999 with 140 tons of limestone sand introduced to six stream locations within the drainage using a helicopter. Improvements to water quality occurred immediately, aquatic invertebrate response was noted within three months and upstream recolonization of some fish species was observed within six months. Water chemistry data have been collected and analyzed quarterly by JMU from 22 sampling locations within the wilderness and weekly samples have been collected at the wilderness boundary. In addition, aquatic invertebrate and fish populations have been surveyed annually. The pH, ANC, calcium concentrations, and calcium/hydronium ratios have all increased as a result of the limestone treatment and have remained at acceptable levels during the 5-year study period. Aquatic invertebrate diversity recovered to levels not seen in 30 years and brook trout numbers initially exploded then settled to levels about 50% higher than long-term pre-treatment averages. In September 2003, Hurricane Isabel dumped up to 51 cm of rain in the drainage and significantly disturbed stream channels and riparian vegetation. Despite the catastrophic flood event, the limestone beds remained intact and continued to provide suitable water quality. The study clearly demonstrates that this treatment method can provide long-term benefits to aquatic resources.

Introduction

Acid deposition has been impacting aquatic resources in the mid-Atlantic and southeastern United States for at least the past two decades (Herlihy, et al., 1993; Webb, et al., 1994). The pH of pre-industrial precipitation in Virginia has been estimated to be in the 5.3 to 5.6 range (Webb, 1987) while recent readings in the Shenandoah National Park averaged 4.4 (U.S. EPA, 1998). This represents a tenfold increase in precipitation acidity since the beginning of the 20th century.

Acid deposition is not necessarily harmful to aquatic life. A watershed's ability to buffer acid deposition determines whether the system suffers long-term biological degradation. In western Virginia, most of the larger stream systems are well buffered due to underlying limestone geology, but most of the wild trout resource occurs on mountain slopes composed of sandstone, quartzite and shale. These slopes provide limited buffering capacity and are subject to acidification. In 1987, a synoptic survey of water quality parameters in 350 of Virginia's 450 wild trout streams was funded by the Department of Game and Inland Fisheries. The result of that investigation indicated that 78% of the sampled waters had ANC (acid neutralizing capacity) of less than 100 ueq/L, meaning they were sensitive to acidification. Of these acid sensitive streams, 11% were already acidified (ANC< 0). One of these acidified streams was the St. Marys River, once considered one of the state's premier wild trout fisheries.

Study Area

St. Marys River is a third order coldwater stream that drains the west slope of the central Blue Ridge Mountains in southeastern Augusta County, Virginia. Its 27 km^2 watershed is the centerpiece of the 4000 hectare St. Mary's River Wilderness Area. St. Mary's River originates at 951 m above sea level and descends at a gradient of 39 m/km to its confluence with Spy Run, 11.4 km downstream. The stream is very scenic with numerous falls, cascades, large boulders and deep clear pools. The watershed includes five major tributaries. St. Mary River's low ANC levels can be traced to the geologic formations that underlie the upper watershed. Antietam quartzite is the primary rock formation while formations of Hampton quartzite underlie the upper watersheds of Sugartree Branch, Mine Bank Creek, Bear Branch, Chimney Branch, and lower reaches of St. Mary's (Werner, 1966). Both formations are known to have low solubility, thus providing few base cations and carbonate to neutralize acidic input (Downey, 1994).

The St. Mary's River has long been recognized as one of Virginia's premier wild trout fisheries. In 1935 (Surber, 1951), it was reported to support a good population of wild rainbow trout. By 1948, the lower portions of the stream began receiving stocked trout as part of the federal/state effort to expand trout fishing opportunity. The floods of 1969 and 1972 eliminated access for stocking and the stream reverted to wild trout management. At that time, St. Mary's River was one of the few streams in the state that contained reproducing populations of brook, brown and rainbow trout. It became one of the state's earliest special regulation streams when the Department so designated it in 1974 after study and recommendations by Trout Unlimited. The drainage was later proposed as a federally designated wilderness and in 1984 became one of Virginia's first wilderness areas. The primary feature of the area that drew support for wilderness designation was the wild trout fishery and the scenic qualities of the St. Mary's River.

Biological Surveys

Surber (1951) provided the earliest data on biological communities in the St. Mary's River. He collected detailed aquatic macro-invertebrate data from a number of sites in both 1936 and 1937. These data provide a valuable baseline which precedes likely impacts due to industrial based acidification. The Department of Game and Inland Fisheries collected extensive fisheries and invertebrate data as part of a statewide trout stream inventory in 1976 (Mohn and Bugas, 1980). With the designation of St. Mary's River as an acidified trout stream by Webb (1987), the Department began a program of intensive fisheries and invertebrate data collection on a biennial basis from 1986 through 1998. Since the liming operation in 1999, fish and invertebrate data have been collected annually.

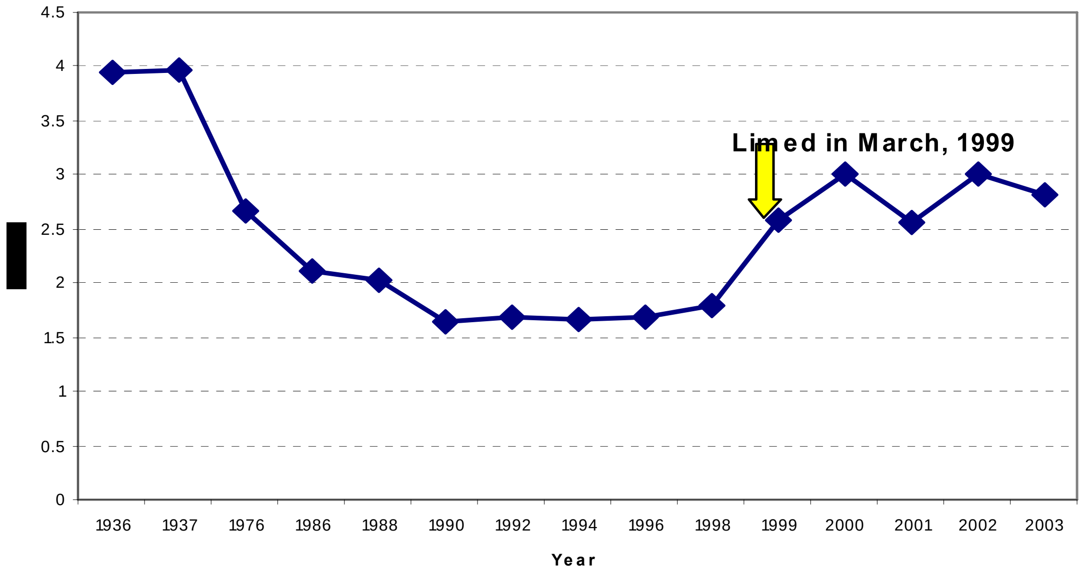
The 1976 survey by the Department of Game and Inland Fisheries provided the first recorded fisheries survey of the St. Mary's River. Six sample stations were established on the mainstem. These stations were established at approximately equal intervals along the mainstem from the lower wilderness boundary to the headwaters (Mohn, et al., 2000). Stations varied in length from 76 to 171 m and included at least three riffle, pool, and run sequences. Block nets were placed at each end of the sample stations and three-run depletions were used to estimate fish abundance and biomass. In addition, a Carle sampler (Carle, 1976) was used to collect three 0.26 m^2 invertebrate samples from riffle areas at each site. This collection technique and the sample locations compared favorably with methods used by Surber in 1936/37.

Fourteen species of fish have been collected from the St. Mary's River since 1976 but several are considered transient. The most species collected in any one-survey year was 12 in 1976. During the pre-treatment survey period 1976 – 1998, the number of fish species steadily declined from 12 to 4. In addition, several species, which were found throughout large portions of the drainage in 1976, such as blacknose dace, fantail darter, and mottled sculpin, had their ranges and numbers severely reduced. Rainbow trout, for which the St. Mary's River was best known, were extirpated from the drainage by 1994. Due to its greater acid tolerance, the native brook trout remained abundant through 1994. However, the 1996 survey indicated year class failures in two of the previous three years and a sharp drop in brook trout population numbers. The magnitude of this drop in population prompted the Department to immediately begin discussions with the USFS on acid mitigation.

The aquatic invertebrate data have shown a more gradual but no less significant reduction in both species numbers and diversity (Kauffman, et. al, 1999). Many genera of stonefly, mayfly and caddisfly were extirpated from the drainage by the mid-1980s while populations of acidophobic taxa such as the Plecoptera, *Leuctra/Alloperla* and Chironomidae showed significant increases. The invertebrate diversity as measured by the Shannon Diversity Index showed a significant decline throughout the pre-treatment study period (Figure 1).

Figure 1

Diversity (Shannon) Index



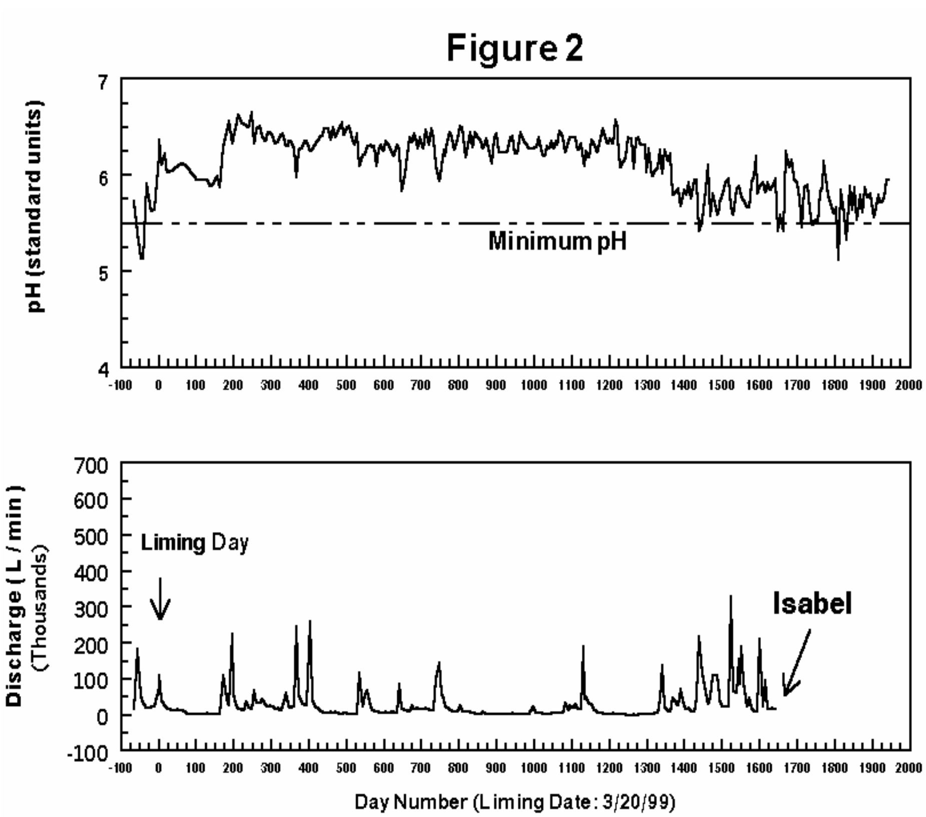
Acid Mitigation Methodology

The USFS, Chemistry Department at James Madison University and Virginia Department of Game and Inland Fisheries have developed a low cost methodology for treating stream acidification using limestone sand introduced directly into the stream (Downey, et al., 1994, Hudy, et al., 2000). This methodology was utilized on March, 1999 when 140 tons of limestone were placed at six sites within the St. Mary's River Wilderness Area using a helicopter (Mohn, et al., 2000). It was estimated that this treatment would effectively mitigate the impacts of acid deposition for a period of five years. Although the use of limestone sand has become a commonly used treatment method in this region of the country, the St. Mary's River project was unique in that it would occur within a federally designated wilderness area. In this instance, there are not only biological and chemical aspects to limestone mitigation, but social, political, economic, and legal aspects as well. The process for dealing with the issues and concerns of treating a wilderness stream are described in Mohn, et al. (2000).

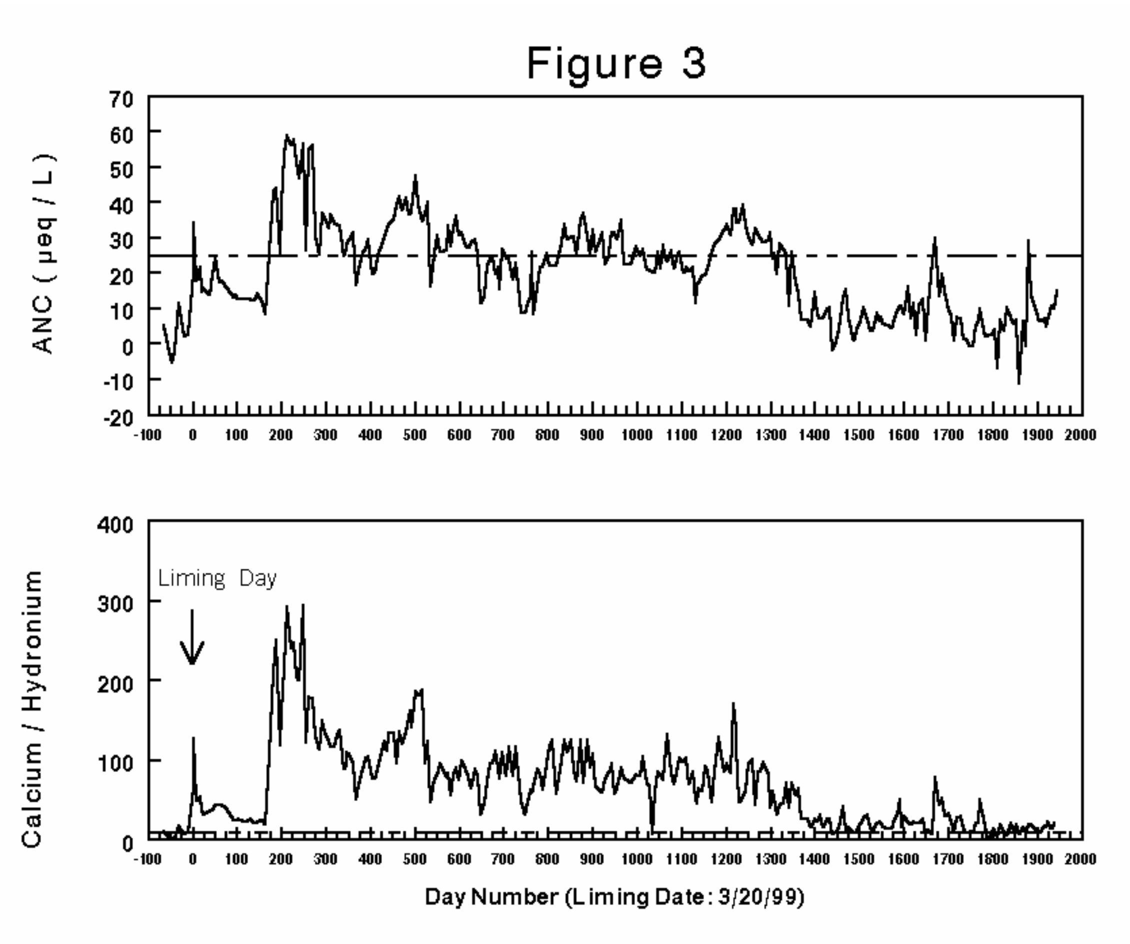
The limestone sand mitigation method is based on placing enough limestone to treat the receiving water for a specified period. In this study, it was estimated that the treatment would be effective for a period of five years. This calculation is based on the consumption rate of the limestone at the average annual rainfall for the drainage. Flow rates for this study period were far from normal. At time of treatment, the area was in the first year of a severe 4-year drought. That period was followed in 2002 with one of the wettest years on record and finished in the fall of 2003 with one of most devastating floods on record. In September 2003, the St. Mary's River drainage took a direct hit from Hurricane Isabel. Rain gauges at the head of the drainage recorded as much as 51 cm of rain within a 18 hour period, far more than fell anywhere else in the storm's path. This discharge resulted in major streambed alteration including establishment of new channels and severe downcutting of the channel bed. This event caused concern for the continued stability and function of the limestone sand beds.

Water Quality Response

Water chemistry monitoring of the St. Mary's River began in January 1999, three months before the date of the liming treatment. A sampling site was located at the lower boundary where the stream exits the Wilderness Area. A staff gauge was installed here for recording stream discharge on sampling days. Samples have been collected no less frequently than once a week since the date of liming. The top graph in Figure 2 provides the observed pH for the 67 months since the project started. The data points are connected for clarity. A value of pH 5.5 was chosen as a minimum for protection of certain aquatic insects and fishes that were native to the St. Mary's drainage. Figure 2 reveals that the pH values were often less than the minimum acceptable value at the sampling site prior to the introduction of limestone. The average value for this period was pH 5.53 $\pm$ 0.26. In the 64 months that have elapsed since the liming, the average has been pH 6.14 $\pm$ 0.30. The bottom graph in Figure 2 shows the peaks and valleys in measured discharge that accompanied wet and dry periods. The graph ends on Day 1645 when the flood after Hurricane Isabel destroyed the gauging site. Storm events generally caused short-term decreases in pH as shown by the graphs, but even the decreases were significantly mitigated compared to the pre-liming conditions. The years 2002, 2003 and 2004 have been wet with above average discharge and it is evident from the data that pH has dropped during that time period. It is interesting to note that pH remained stable after the Hurricane Isabel flood, indicating that the limestone sand beds are effect even under catastrophic conditions. The pH drop, however, does signal a need for reliming.



Another water quality parameter of interest is the acid neutralizing capacity (ANC). Figure 3 provides the weekly ANC data on the top graph. The bottom graph in Figure 3 shows the calculated parameter of calcium to hydronium ion (Ca/H) ratio versus time. These are included in the same figure because both parameters are important for assessing the impact of acidity on aquatic life. The ANC values were quite low for the St. Mary's River prior to liming, often showing negative values. The pre-liming ANC average was 2.1 $\pm$ 5.0 µeq/L. The low values are the result of a lack of carbonate bearing mineral in the Antietam formation of quartzite rock that makes up most of the St. Mary's wilderness watershed. Thus little natural buffer is available to mitigate acidic inputs. The post-liming ANC values have increased due to the slow dissolution of the introduced limestone sand to an average 21.3 $\pm$ 12.7 µeq/L.. Recently the ANC values have fallen below the target also indicating that reliming will be necessary soon.

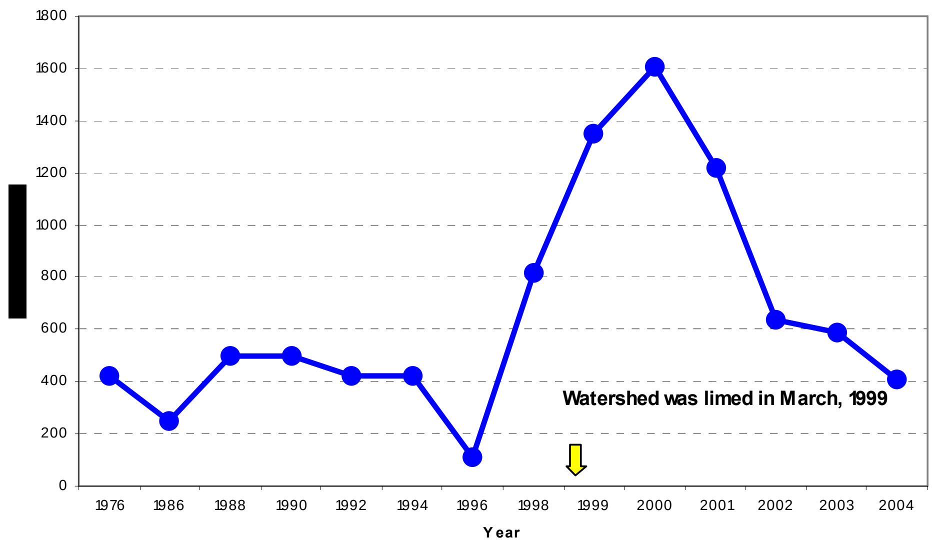


Biological Response

Post treatment trout biomass and number estimates show a dramatic response (Figure 4). However, all of this response cannot be attributed to the limestone treatment as populations began recovery in 1998. Virginia experienced a prolonged drought period that resulted in stable, low flow, mild winters from 1997 through early 2001. These conditions generally produce exceptional year-classes of brook trout. In the case of St. Mary's River and other acidified streams, the low flows not only produced good flow conditions for reproduction and recruitment but the lack of significant rainfall resulted in winter pH values higher than normal. However, brook trout numbers leveled off in 2002 and 2003, both high low years, at about 600/km which is about 50% higher than the pre-treatment average. The sharp decline in 2004 is attributed to the severe impact of Hurricane Isabel.

Figure 4

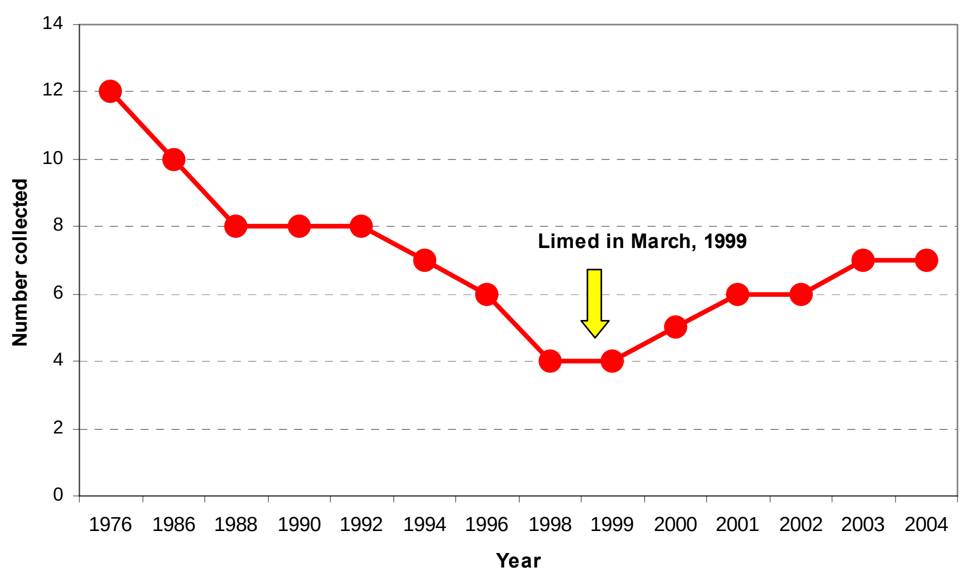
St. Marys Brook Trout Density



Non-game fish species have also shown a recovery. Prior to treatment, St. Mary's contained only 4 species of fish with only brook trout present in significant numbers. The number of species has now increased to 7 (Figure 5) with most species now present in good numbers at lower sampling sites.

Figure 5

St. Marys River - Fish Species Collected



The aquatic invertebrate populations, as measured by the Shannon diversity index, has been our most reliable indicator of stream decline over the history of our studies of the St. Mary's River. It is interesting to note that the index rebounded to 1976 levels within only 3 months of treatment (Figure 1) and has remained fairly consistence throughout the study period.

Conclusion

The use of limestone sand has proven to be an effective and cost efficient method of treating stream acidification. Stream discharge has varied significantly during the study period, yet the treatment remained effective at mitigating acidification. Despite a catastrophic flow event late in the study, the limestone sand beds remained intact and continued to be effective. The original methodology (Mohn, et.al., 2000) used to estimate the quantity of limestone needed to cover a minimum five-year treatment period appears to have been appropriate. The data indicate the need to add additional lime in the near future.

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Wild Trout in an English Chalk Stream: Modeling Habitat Juxtaposition as an Aid to Watershed Rehabilitation

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ABSTRACT—Wild brown trout (*Salmo trutta*, Linnaeus, 1758) populations in southern England are subject to both habitat degradation and overstocking, even in the internationally famous streams where dry fly-fishing began. Habitat rehabilitation within such degraded watersheds can be improved by better understanding the integration of habitat and ecological processes operating simultaneously at a range of scales. We quantify the influence of local meso-habitat juxtaposition upon wild brown trout population dynamics in two contrasting sectors of the River Piddle, Dorset, UK. Sectors examined represent 'typical' semi-natural chalk-stream conditions in the Piddle/Frome Watershed. PHABSIM was used to model meso-scale habitat composition (WUA) and habitat durations, which were tested for correlation against age-specific trout densities, obtained from eight years quantitative electrofishing data. Analyses indicate; **(1)** availability and location of marginal meso-habitats with abundant cover is critical to adult over-winter survival and **(2)** appropriate juxtaposition of spawning and rearing meso-habitats strongly influence juvenile brown trout recruitment. In the light of these data we examined the potential for integrating meso-habitat juxtaposition into initial design stages of river rehabilitation schemes. We argue that such an approach should form an integral component of watershed restoration strategies as it offers effective manipulation of natural mechanisms regulating brown trout populations at a multi-scalar level.

Introduction

The brown trout (*Salmo trutta* Linnaeus 1758.) is a polymorphic species indigenous to British rivers but there is considerable evidence of widespread and on-going decline in the status of wild stocks (Giles, 1989; Crisp, 1989). Anthropogenic influences destructive to river channel structure and ecosystem function cause widespread and severe loss of salmonid habitats (Crisp, 1989; White, 2002). In the UK, rivers have been so modified and engineered for purposes such as flood defence, land drainage and navigation that few can be regarded as in a "pristine" condition (Brookes and Shields, 1996). In recent decades, increasing development of floodplains has increased the need for river engineering to improve flood defence. Population growth, particularly in the south of England, has increased pressure on groundwater resources. In addition, on-going degradation of logic environments is largely due to agricultural land use practises associated with intensification under the EU Common Agricultural Policy (CAP). Large scale dredging programmes in the 1950's and 1960's aided wetland drainage in order to bring fertile floodplain land into production. Soil erosion from ploughed arable land increases sediment supply to rivers and exacerbates problems of eutrophication caused by intensive application of fertilisers. Destruction of river banks by sheep and dairy cattle in over-grazed riparian zones has become a major source of habitat loss everywhere from southern chalk streams to Scottish mountain burns. The recent "Salmon and Freshwater Fisheries Review" (Warren, 2000) recognised the need to place habitat enhancement at the core of wild stock conservation and recommended urgent research into factors affecting long-term sustainability and effectiveness of habitat restoration as a fisheries management tool. In this context the present study addresses the response of a wild brown trout population to temporal and spatial variation in stream habitat and, in particular the influence of local meso-habitat juxtaposition on population structure in a small chalk-stream.

The Study Area

The River Piddle is a third order stream draining a catchment of Upper Cretaceous Chalk approximately 183 km^2 in area and flows approximately 40 km south and east to form a common estuary with the River Frome, before discharging into the English Channel via Poole Harbour. Land use on the floodplain is predominantly permanent pasture and arable land. The Piddle is a typical "chalk stream" characterised by low mean gradient (2.18m/km) and base-rich alkaline waters ($CaCO3$ > 200 mg/l). Groundwater rises at a relatively constant 9-10^{o}C throughout the year maintaining stable seasonal and diel temperature regimes. The buffering effect of the aquifer produces a stable flow regime with an absence of extreme low flows and sudden spates. Winter high flows rarely exceed bankfull stage and summer base flows are maintained by groundwater (Mann et al.,1989). Long-term mean monthly flows at Tolpuddle (1965-2000) range from 0.18 m^3/s in August/September to 2.4 m^3/s in February. Median flow (Q50) over the period is 0.54 m^3/s. Primary production is dominated by large aquatic macrophytes, mainly *Ranunculus* spp. which supports high macroinvertebrate productivity forming the basis of trout diet (Maitland and Campbell, 1992). Dominant fish species are resident and anadromous brown trout and Atlantic salmon, with minnow, bullhead, stone loach, pike, and eel common (Strevens, 1999).

The morphology of low gradient chalk streams tends to produce more habitat features, such as undercut banks, trench pools and low width-depth ratios, in comparison to moderate gradient reaches, and these features are positively correlated with a high mean standing stock of trout (Kozel et al., 1989). However, the Piddle has suffered many problems common to intensively farmed lowland catchments. Physical habitat degradation from overgrazing resulting in loss of riparian vegetation has led to widespread channel over-widening and increased sedimentation. Habitat diversity has been lost due to historical anthropogenic manipulations particularly associated with milling, irrigation and land drainage. Run-off from agricultural land has caused siltation problems detrimental to salmonid spawning (Crisp, 1989) and elevated nitrate levels have resulted in widespread algal colonization of substrates. The catchment is heavily abstracted for a variety of water uses which has exacerbated low flow problems since the mid-1980s. This has had significant ecological impacts including severe reduction in juvenile trout habitats over a 10-km length of the middle river (Strevens, 1999).

A programme of physical restoration was initiated at Tolpuddle in 1994 primarily to restore channel diversity and improve spawning habitat and refugia for larger wild trout (Summers et al., 1996; Summers et al., 1997). Fencing and substrate re-distribution using current deflectors and weirs were the most commonly used techniques (Langford et al., 2001). The fishery has been managed for over twenty years on a "catch and release" basis and retains a significant self-sustaining population of native resident and anadromous brown trout, which is not subject to angler harvest, or stocking of hatchery trout. Pike (*Esox lucius*) which were present prior to 1993 were removed and subsequently controlled to alleviate the effects of piscivorous predation and physical habitat was assumed to be the most important population-limiting factor. The study site comprised two main stem river sectors approximately 2 km apart and 0.5 km in length both divided into 4 electrofishing sections. The trout population was monitored annually by electrofishing in early autumn over the period 1993-2001.

Methods

Two representative reaches of contrasting habitat characteristics and population dynamics were selected for both sectors for application of the Physical Habitat Simulation Model (PHABSIM). Both reaches were coincident with electrofishing sections. Sector 1 was of higher habitat diversity flowing through fenced open pasture with a trout population dominated by adults. Sector 2 was more uniform, partly over-shaded by riparian trees and consisted principally of age 0+ and 1+ trout.

Hydraulically linked transects were used to characterize hydraulic and physical habitat attributes of each study reach in accordance with PHABSIM requirements (Bovee et.al., 1998). Transects were placed to represent mesohabitat types present in approximate proportion to the contribution of each habitat type to the total make-up of the river sector. Approximate cell boundaries were determined from habitat mapping and located at intervals ranging from 5 – 23m depending on microhabitat complexity. All mesohabitats present were represented by at least one transect to accurately represent habitat availability and continuity thus ensuring that habitat juxtaposition was accurately sampled. Field measurements of depth (cm), and mean column velocity (m/s) at 0.6 depth at each transect were taken for a minimum of three discharges over one hydrological cycle as outlined by Bovee et al. Substrate and cover were measured twice (summer and winter) at corresponding intervals between 0.3 – 0.6 m along transects to define a series of cells around measurement points. Hydraulic models were calibrated using standard procedures described by Elliott et al, (1996). The stage discharge and water surface profile models were used to simulate hydraulic characteristics for each cell at specified discharges, the latter being more reliable for simulating flows above the highest calibration flow. Category 2 Habitat Suitability Criteria developed for brown trout on the River Piddle (*Bird et al, 1995*) were used in the HABTAE programme to calculate composite suitability indices for cells that were aggregated to derive total Weighted Useable Area (WUA) and mesohabitat WUA for each reach.

Time series were derived from habitat (WUA) – flow functional relationships in order to show duration and extent of habitat availability. Monthly time steps were aggregated into seasonal time steps as follows; (1) winter habitat durations (Nov – Mar) for spawning/incubation and adult life stages (2) summer growing season habitat (June – Oct) for fry and adult life stages. Habitat specific time series were also generated for meso-habitat types using the same procedure. Indices of habitat availability were developed representing different perspectives of the time series for each trout life stage. For example, habitat shortages during a particular season were evaluated using minimum habitat to represent acute low habitat events and the mean of the lowest 50% of values was used to depict longer-term effects of habitat minima. Habitat metrics were also developed for "near-shore" zones within 2 metres of the bank to evaluate importance of marginal habitats and for specific meso-habitat types. Length-frequency histograms of trout numbers allowed three age cohorts to be identified corresponding to fry (age 0+), juvenile trout (age 1+), and adult trout (age >1+). Trout abundance (N) in each age class was expressed in terms of density (N/m^2) to take account of variations in area between reaches and was used to assess annual changes in population structure in response to temporal habitat variations.

Linear regression analyses and Pearson correlation coefficients *(r)* were used to test for association between age specific trout densities and habitat (WUA). Where appropriate habitat data were natural log transformed in cases where variances exceeded mean values in order to stabilise variance and approximate a normal distribution, as in Nehring and Anderson (1993). The nature of the variables was such that associations could be assumed to be uni-directional and thus one-tailed tests of significance were employed. Relationships where $p < 0.05$ were considered to be significant.

Results

Adult Trout

Winter habitat durations (Nov – Mar) demonstrated effects of low mean monthly flows (MMF) in winter in depressing adult habitat availability. Moderate to high winter flows ($MMF>1.0m^3s^{-1}$) made little difference. Time series for streamside marginal habitats indicated these were a critical resource for adults in winter (fig. 1). Seasonal variations in marginal habitat showed that adult habitat availability was greater in winter than in summer, winter habitat exceeding summer habitat 80% of the time.

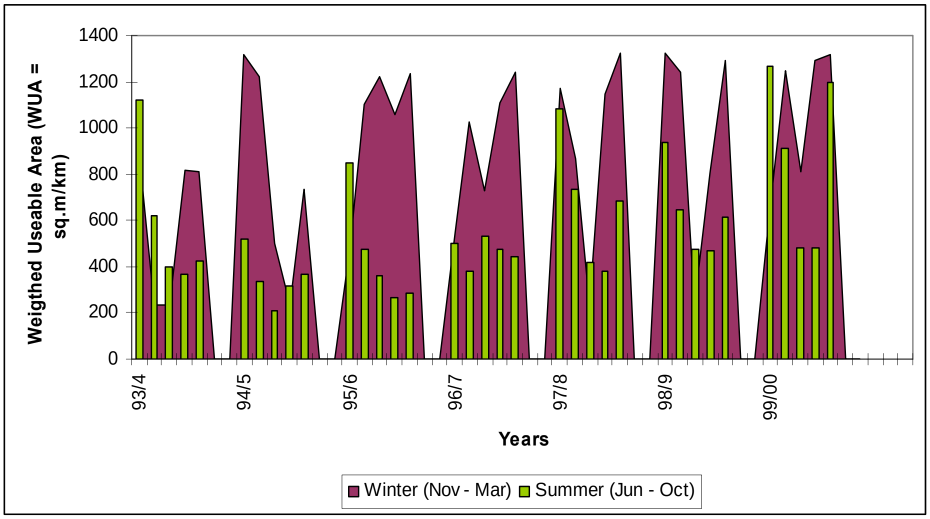

Fig 1. Time series comparison of mean monthly marginal habitat durations for adult trout in summer and winter

Adult densities were strongly correlated with winter habitat metrics (fig. 2) but no significant relationships with summer habitat were present in any study reaches. Availability of high quality marginal habitats in winter accounted for 91% of variation in adult densities in the upper sector but there were no associations with mean winter habitat suggesting overall habitat availability was relatively unimportant for adults compared to marginal habitats.

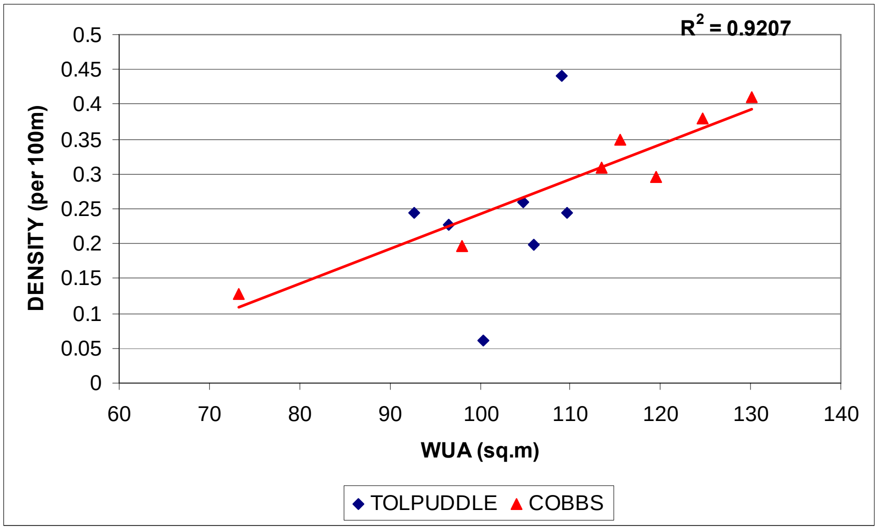

Fig 2. Relationship between annual adult density (1994 – 2000) and mean marginal habitat winter (WUA) for adults

Juveniles Trout: Spawning

Riffle zones provided better quality spawning than glides and pools over most of the simulated flow range except at very low winter flows (below 0.2 m^3/s) when glides provided the best areas (fig. 3). Most spawning habitat was consistently available when winter flows fluctuated between approximately 0.5 – 2.0 m^3/s showing the importance of a stable flow regime over the egg deposition to hatching period. Moderate flows during incubation, hatching and swim-up/dispersal of fry (Jan – Mar) resulted in the strongest 0+ year classes.

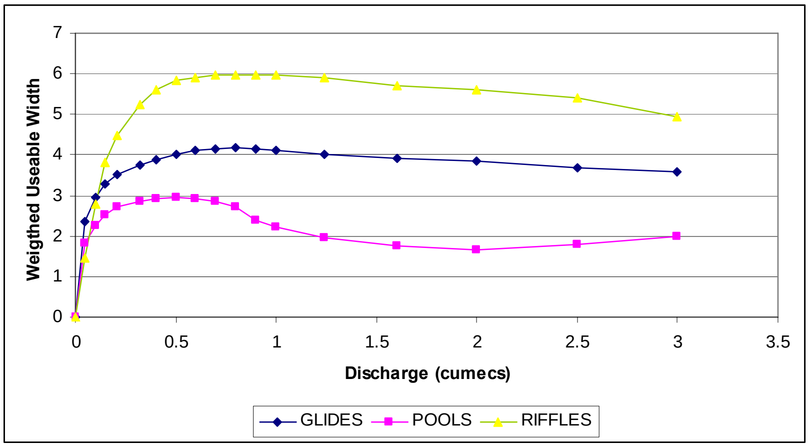

Fig 3. Habitat - discharge relationships for selected meso habitats

During the critical (hatching) period in February/March, mean spawning habitat availability in riffles was significantly correlated with densities of 0+ trout accounting for 65% of variability (*F=9.33; p=0.028*) (fig. 4). Mean riffle habitat was more highly correlated with fry density than total spawning WUA during the same period (r^2 = 0.65; p = 0.014 and r^2 = 0.59; p=0.025 respectively). There were no relationships with spawning metrics for other time periods. Densities of trout age 1+ the following year were significantly correlated with riffles and glides but showed a stronger association with glides. Mean glide hatching period (r^2 = 0.74, p=0.014) was virtually as good a predictor of juvenile density as total mean hatching period in the upper sector (r^2 = 0.82, p=0.006).

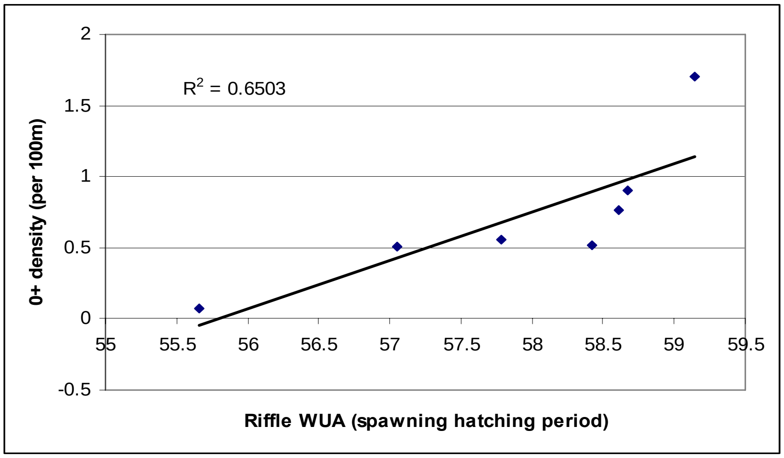

Fig.4. Relationship between spawning habitat in riffles during incubation/hatching period (February/March) and 0+ densities the following September

Juveniles Trout: Summer growing season

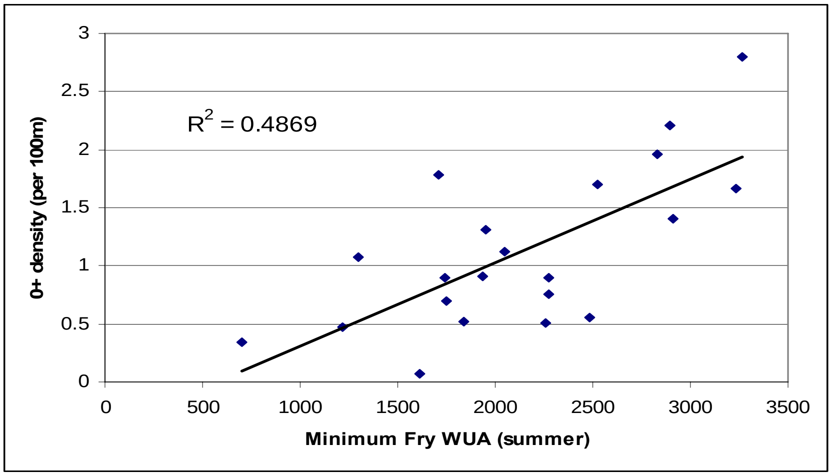

Fig. 5. Relationship between minimum fry rearing habitat during the first summer and 0+ density in September

Young-of-year habitat during the first growing season was positively correlated with 0+ fry densities in both reaches. Average summer habitat (July – September), summer minima and near shore habitat metrics were the best predictors of fry densities. Habitat predictions for young-of-year growing season combined for all reaches produced significant correlations with 0+ densities (r^2 = 0.49; p=0.001). Minimum monthly habitat availability was the best predictor of fry densities, accounting for 49% of variance (F= 18.1; p<0.01) (fig.5).

In the lower sector all meso-habitat metrics (except maxima) were significantly positively correlated with 0+ density for the three meso-habitat types present (riffles, glides, flats) but no one habitat type was found to be more important. Time series analysis of meso-habitat durations indicated that spawning habitat was in the order of 50% greater in riffles relative to glides but glides were more important as summer rearing habitats (fig. 6).

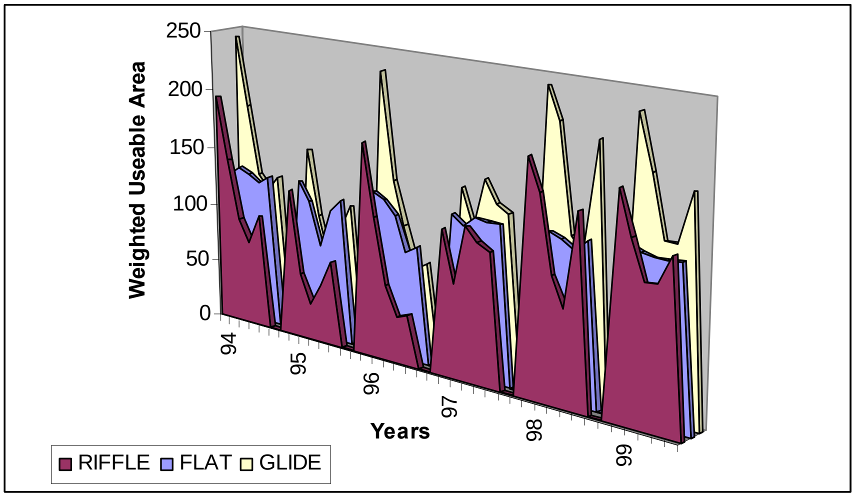

Fig 6. Time series (1994 – 1999) showing variations in summer habitat (WUA) for 0+ trout during the first growing season (June – October) in selected meso habitat types.

Metrics developed for a glide-riffle-glide habitat assemblage, which represented the best juxtaposition of rearing habitats significantly explained between 30 – 44% of variance in 0+ and 1+ densities. The best overall predictor of 0+ densities across all reaches was a combination of spawning WUA during the critical hatching period and minimum rearing habitat availability in summer. A multiple regression model indicated these two metrics explained 68% of variation in 0+ densities (F=19.28; p<0.01).

Discussion

Analysis of population data suggested population size was primarily regulated by year on year variations in recruitment of 0+, which showed an increasing trend with time and increased in relation to spawning stock size. Substantial increases in the ratio of adults to young-of-year in the Lower sector indicated pike predation was probably a major population-limiting factor at the commencement of the study period. Trout biomass becomes asymptotic in later years indicating that, even in high productivity chalk streams, density can have a major effect on growth, and that biological productivity may have become a more important limiting factor than physical habitat in the Lower River.

However, availability of spawning and rearing areas played a fundamental role in limiting 0+ recruitment, especially where local recruitment was evident. Our findings indicated that juxtaposition of spawning and rearing meso-habitats strongly influenced juvenile brown trout recruitment. The importance of riffles and glides was evident and the significance of longer-term summer habitat minima associated with low flows in the first growing season was marked, especially in the lower sector where 0+ densities were highest. This is in line with the findings of Elliott (1994) who demonstrated that spawning success in a Cumbrian stream had no effect on densities of surviving fry, which were regulated by density-dependent mortality in response to low amounts of nursery habitat. Time series of meso-habitat durations for young-of-year showed significant increases in contributions of riffles and glides to summer habitat in later years (Fig. 6). This reflects the role of flow augmentation in reducing critical low flow periods and consequent habitat depletion that caused widespread reductions in juvenile stocks throughout the middle catchment up to the mid 1990's (Strevens, 1999). These habitat increases corresponded with ongoing upward trends in 0+ densities throughout the study area over the survey period. The high densities of 0+ and 1+ trout in the lower reach demonstrated competitive segregation with juveniles dominant in the upper part and fry in the lower part. 1+ trout tend to be dominant and expel 0+ fry to shallow riffles and low velocity river margins where they are most commonly found (Bohlin, 1977; Cunjak and Power, 1986). In the upper sector where 0+ recruitment was low, the importance of spawning riffles to year class strength was more apparent, possibly due in part to lower availability of early rearing habitat and intra-specific competition between fry and parr.

Adult brown trout normally maintain station close to a shelter (Boussu, 1954; Heggenes, 1988b) and availability and diversity of cover have a significant effect on population density by increasing the numbers of territories and hence stream carrying capacity. In the Upper sector where the relative proportion of adults was higher, winter availability of meso-habitats associated with abundant marginal cover were critical to over-winter survival. Brown trout tend to have a strong preference for positions beneath overhead cover (Lewis, 1969), either above stream cover (<1m) or in-stream submerged cover. In summer, overhead cover provides shading that is important to adult trout, which become increasingly negatively phototropic as they develop progressively stronger shelter seeking behaviour with age (Bachman, 1984; Bagliniere and Maisse, 1999). In chalk streams, expansive tresses of ranunculus providing both velocity shelter and submerged overhead cover are abundant throughout the channel in summer. This abundance together with the relatively lower importance of "edge" habitats probably explains why no relationships with adult population size were observed. In winter, overhead cover can become a critically limiting resource often restricted to the stream margins where die-back of lush emergent marginal plants creates long tangled rafts of weed which snag around obstructions and woody debris creating complex cover zones of overhead and obstacle cover. When combined with sufficient depth these "features" provide excellent winter refugia for larger trout. Cunjak and Power (1986) demonstrated that association to cover was significantly greater in winter than summer for brown trout and that submerged cover was utilised more frequently than above water cover (Cunjak and Power, 1987). Low water temperatures may encourage adults to seek out habitats characterised by slower velocities than preferred in summer in response to reduced nutritional requirements, drift availability and the need to conserve energy (Cunjak and Power, 1986). Territorial behaviour also tends to decrease as temperatures fall and feeding ceases with the onset of winter (Mason and Chapman, 1965; Cunjak and Power, 1986). The lack of variation in adult densities and the strength of the association with marginal cover ($r^2 = 0.92$) suggest that available winter habitat is the primary factor limiting adult carrying capacity at the reach scale. Our findings support the view that submerged cover is an important factor effecting winter survival of salmonids and that in small lowland streams marginal cover is a critical determinant of carrying capacity.

A juxtaposition of micro-habitats comprising a variety of specific stations used at different times makes up a trout “home range” (Shirvell and Dungey, 1983). The limited movement of resident brown trout in chalk streams (Soloman and Templeton, 1976) suggests habitat selection that enables trout to complete their life cycles within a relatively “local” area (Bachman, 1984). Thus, habitat juxtaposition is important in mitigating life history strategies of brown trout populations. Greater habitat diversity increases the likelihood that a self-sustaining population will be maintained by “local” adult stock. Furthermore, better understanding of the importance of different meso-habitat combinations for different life stages offers a means of enabling river rehabilitation schemes to more effectively manipulate natural population regulating mechanisms.

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Volunteers as an Integral Component of the Fisheries Program in Yellowstone National Park

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ABSTRACT—During the past decade, integrity of Yellowstone National Park aquatic resources has been threatened by a convergence of nonindigenous species. Priorities for research and monitoring have shifted and a majority of funding for fisheries in Yellowstone is now directed at the new emerging crises. At the same time, there are many basic questions regarding park fisheries that require immediate attention. To address this issue, a new program was established that brings dedicated volunteers, mostly from the angling community, to Yellowstone where they can participate as a member of a team directed at projects using fly-fishing as a collection technique. In 2002 and 2003, 114 fly-fishing volunteers from throughout the United States assisted with several specific fisheries projects, directed at genetic status, life history patterns, and species composition. The fly-fishing volunteer program has been successful at educating the public about fisheries issues in Yellowstone while providing a useful database of information for park biologists, garnered through stream and lake sampling with rod and reel. Future efforts will include a study where fish population information as measured by electrofishing is compared to that collected by fly-fishing. If similarities exist, angling could potentially be used to estimate other important fish population metrics.

Population Trends and an Assessment of Extinction Risk for Westslope Cutthroat Trout in Select Idaho Waters

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ABSTRACT—Despite westslope cutthroat trout (*Oncorhynchus clarki lewisi*) being petitioned for listing under the Endangered Species Act, formal evaluations of extinction risk for the sub-species have been quite limited. In this study, we summarize existing population trend data for westslope cutthroat trout, use the trend data to estimate population growth rates, and combine these with various likely initial population sizes to assess generalized extinction risk for westslope cutthroat trout within select Idaho drainages. Population data consisted of over 30 years of snorkel trend counts for westslope cutthroat trout across a broad geographic area in Idaho. Results of trend analysis including both inspection of graphs, and calculation of infinitesimal growth rates, indicate that westslope cutthroat trout have maintained or increased their population abundance over a large area within the state of Idaho during the past 15-34 years. Total estimates of westslope cutthroat trout numbers within various Geographic Management Units (GMU's) conservatively range from 6,500 to 341,000 fish, with a combined estimate of approximately 1.2 million fish for the GMUs considered in this study. Mean sub-basin population size ranged from about 400 to 13,000 fish. Population persistence for 100 years ranged from high to low for various individual local populations. However, the study results suggest that numerous sub-populations within most GMU's, available to interact within a classic or less traditional metapopulation framework, would result in a high ($\geq$ 95%) probability of westslope cutthroat trout persistence over 100 years.

Introduction

The westslope cutthroat trout (*Oncorhynchus clarki lewisi*) is one of two recognized sub-species of cutthroat trout residing in the Columbia and upper Missouri river basins. Although westslope cutthroat trout have been the subject of numerous localized investigations, relatively few authors have focused on general sub-species status on a broad geographic scale. McIntyre and Rieman (1995) noted that range declines have occurred across historic westslope cutthroat trout range. Causes of declines include predation by, and competition with exotic native species, overharvest, genetic introgression, habitat degradation and fragmentation (Liknes and Graham 1988; Rieman and Apperson 1989; Thurow et al 1997).

Westslope cutthroat trout were petitioned for listing under the Endangered Species Act in 1997. This petition was initially found to be unwarranted by the United States Fish and Wildlife Service (USFWS) which concluded that a large number of westslope cutthroat trout populations exist across the sub-species range (Federal Register 65Fed.reg.20120). However, a subsequent legal decision required the USFWS to reevaluate the status of westslope cutthroat trout. Results of the second evaluation completed in 2003 also concluded that the sub-species does not need ESA protection (Federal Register 68.reg.46989).

Despite two formal ESA reviews, quantitative evaluations of extinction risk for westslope cutthroat trout populations using Population Viability Analysis (PVA) have been quite limited. McIntyre and Rieman (1995) summarized data for 6 westslope cutthroat trout populations in Idaho and Montana, and calculated variances of infinitesimal rate of growth. Using the modeling approach of Dennis et al. (1991), the authors concluded that stochastic extinction risk will increase sharply for populations that drop to fewer than 2000 individuals. They assumed their study populations varied around an equilibrium with no long-term trend in population number. Thus, their results represent risk associated with random and not deterministic factors. Using a complex Bayesian modeling approach, Shepard et al. (1997) estimated extinction probabilities for 144 westslope cutthroat trout populations in the upper Missouri River basin in Montana. Ninety percent of the populations evaluated had a high or very high probability of going extinct during 100 years based on model projections.

The studies of McIntyre and Rieman (1995) and Shepard et al. (1997) suggest that some westslope cutthroat trout populations could be in jeopardy of extinction but the applicability of those findings to the entire sub-species range is unknown. For example, Shepard et al. (1997) noted that most of the populations considered in their study were small and resided in isolated headwater stream segments less than 10 km long. In Idaho, the presence of fluvial populations in large river systems within the Federal Wilderness system with histories of restrictive fishing regulations dating back 30 years or more may provide increased population resiliency.

In this study, we 1) summarize existing population trend data for westslope cutthroat trout to provide perspective on their current status in Idaho, and 2) use these trend data to estimate population growth rates and combine these with rough approximations of population sizes to assess generalized extinction risk for westslope cutthroat trout within select Idaho drainages.

Methods

Population Trends

Historical snorkel counts

With assistance from IDFG personnel, we summarized snorkeling data collected over three decades from mainstem river sites in four westslope cutthroat trout streams including the St. Joe, Coeur d'Alene, Selway, and Middle Fork Salmon rivers. Snorkeling techniques used on these rivers are similar and described in detail in Rankel (1971), Corley (1972), Lindland (1974), and Johnson and Bjornn (1978). Briefly, one or two divers float downstream counting all westslope cutthroat trout observed, either in the entire stream channel or within prescribed counting lanes.

Snorkel counts were begun on 27 sites on the mainstem St. Joe River in 1969, 29 mainstem and tributary sites on the Coeur d'Alene River in 1973, 27 sites on the Selway River in 1973, and 12 sites on the Middle Fork Salmon (Figure 1). Snorkel site lengths and/or counting lane widths were measured periodically during the sampling periods to ensure the same reaches were being sampled and to enable calculation of fish densities (fish/100m^2).

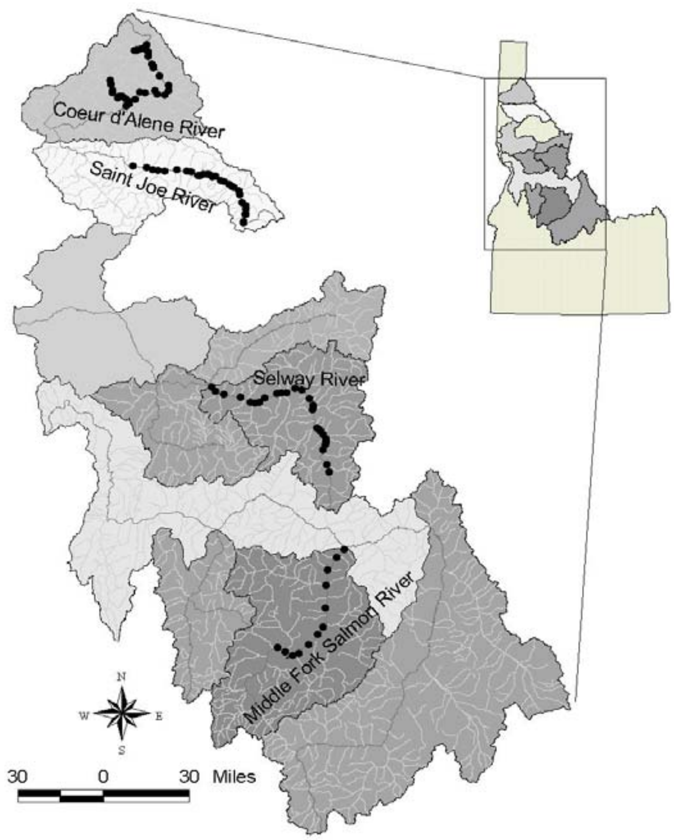

Figure 1. Location of historical snorkel count sites used to monitor westslope cutthroat trout abundance in Idaho, 1969 to present.

General Parr Monitoring counts

In addition to the above historical counts, a sizeable number of additional snorkel count sites have been established for a shorter time across many waters within westslope cutthroat trout range in Idaho. Since 1985, these trend counts have been conducted by IDFG personnel funded via several Bonneville Power Administration-funded research projects as part of what has been termed General Parr Monitoring (GPM). Although originally designed to track trends for anadromous species, observations on all resident fish present have been recorded as well. The dataset contains cutthroat trout density estimates for a few mainstem river sites, but the bulk are conducted in smaller tributary streams typically snorkeled by crawling upstream. Petrosky and Holubetz (1986) provide a more detailed description, including snorkeling techniques, physical parameter measurements, and conversion of raw fish counts to densities (fish/100m^2).

To evaluate westslope cutthroat trend using the above data, we first subdivided the area containing snorkel counts into Geographic Management Units or GMU's (Figure 2) (Lentsch et al 1997). GMU's were large segments of major drainages likely to contain metapopulations (Hanski 1991) based on expert opinion and on extensive westslope cutthroat movement studies conducted in the past (Bjornn and Mallet 1964; Hunt and Bjornn (1991). For each GMU, we subsequently queried the General Parr Monitoring database (J. Griswold IDFG, unpublished dataset) for those snorkel sites where 1) counts were conducted in 10 or more years since 1985 and 2) where 1 or more westslope cutthroat trout were observed during the entire counting period (Figure 2). These individual monitoring sites average about 100 m in length and ranged in number from 1 to 10 on individual streams. Mean density (fish/100m^2) of westslope cutthroat trout observed from 1985 to present was calculated for all such monitoring sites within each GMU. We subjectively considered five individual snorkel sites as the minimum necessary to derive mean trend values for a GMU.

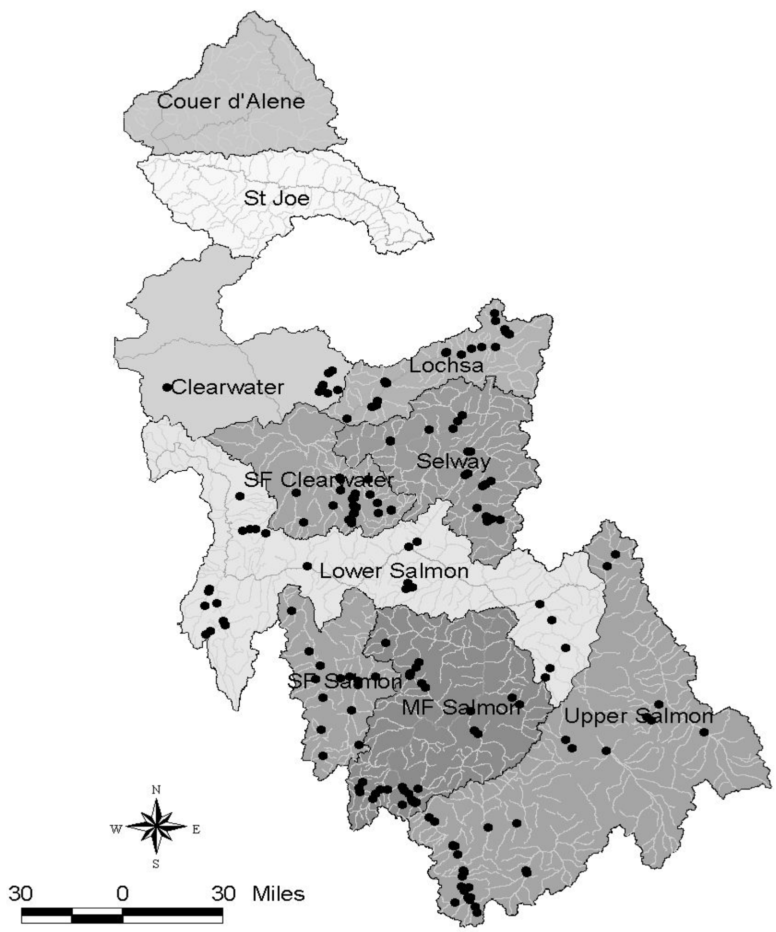

Figure 2. Streams in Idaho westslope cutthroat range within 10 Geographical Management Units (GMUs) and location of GPM snorkel sites (n=206) with ten or more years of data and where WCT were observed in at least one count year.

Estimation of GMU Population Sizes

To approximate the number of westslope cutthroat trout residing in select GMUs we began by summarizing stream lengths inhabited by westslope cutthroat trout in those basins. We relied on the most recent IDFG estimate of inhabited stream kilometers in Idaho within each GMU, derived from existing population data and professional judgment as summarized in a 2002 multi-state status review (Shepard et al. 2003).

In addition to those sites monitored over many years for trend information, the GPM database contains a large number of snorkel sites where one-time population estimates are conducted. The entire GPM database consists of 6,300 counts of trout and salmon abundance conducted at 2300 different sampling locations scattered across anadromous fish-bearing portions of the state since 1985 (IDFG, unpublished data). We considered all GPM snorkel estimates conducted during the period 1996-2000, including those with and without westslope cutthroat trout present, useful in approximating current cutthroat trout population size for a GMU. For all such snorkel counts, the number of westslope cutthroat trout observed was divided by the length of stream snorkeled to obtain a linear estimate of fish density (fish/km). We subsequently calculated mean linear densities of cutthroat observed for each GMU.

To estimate total GMU-wide population sizes, the estimates of stream km occupied by westslope cutthroat trout within each GMU described above were multiplied by the mean estimate of linear density (fish/km) for the sub-species in the same GMU. Because the GMU boundaries we originally selected for the Upper Salmon and Lower Salmon GMU's did not coincide with geographic subdivisions used in mapping present westslope cutthroat distribution (Shepard et al. 2003), we did not attempt to estimate total population sizes for these two areas.

The extinction risk modeling effort below evaluates the effect of multiple subpopulations on persistence probabilities for westslope cutthroat within an entire GMU. Stream basins from third to fourth order in size are thought to mark the boundary between local sub-populations of westslope cutthroat trout (B. Rieman, USFS, pers. communication). To provide a rough approximation of average sub-population size in the various study waters, we used ArcView GIS software to calculate the proportion of stream kilometers within third and fourth order basins for each GMU. This value was multiplied by the total GMU-wide population estimate above. We subsequently divided these estimates by the number of third or fourth order drainages within a GMU to yield approximate mean sub-basin population sizes.

Extinction Risk Modeling

We analyzed westslope cutthroat trend data from both the historical and GPM snorkel counts above using the stochastic exponential growth model of Dennis et al. (1991). The mean instantaneous rate of population change (μ) and the variance in rate of change (σ^2) were calculated for trend datasets within each GMU using STOCHMVP, a software program developed to facilitate use of the Dennis model (E.O. Garton, Dept of Fish and Wildlife Resources, University of Idaho). For those GMU's where two sources of long-term data were available (Middle Fork Salmon and Selway rivers), the longer of the available datasets was used to estimate μ and σ^2.

We utilized estimates of these two parameters and a range of population sizes to estimate probability of single populations persisting for 100 years within the various GMU's, again with the aid of the program STOCHMVP. As in Reiman and McIntyre (1993), the sensitivity of model results to a persistence threshold was evaluated by comparing results for two arbitrarily selected thresholds; in the present study 10 and 100 fish.

Estimates of μ are often imprecise and a given value can have major impacts on extinction risk using the Dennis model (Goodman 2002). Accordingly, we estimated the probability of persistence for individual populations of westslope cutthroat trout in various GMU's using two estimates of instantaneous growth rate. These values included a calculated growth rate from observed data, along with the associated variance estimate, and an assumed μ of 0.0 reflecting a population at equilibrium (Rieman and McIntyre 1993). The equilibrium growth rate was assumed to have a variance identical to the observed value for a given GMU.

Many of the large, relatively pristine drainages in Idaho that are protected by wilderness designation likely harbor numerous local populations in a metapopulation structure (Hanski 1991). Accordingly, the probability of persistence (100 years) for a single large population composed of multiple sub-populations was also estimated as $1-(P_1 \cdot P_2 \cdot \ldots . P_i)$ where P_i = the probability of falling below the threshold in each of the i sub-populations (Rieman and McIntyre 1993). This process was repeated for three paired μ and σ^2 values likely to encompass the range for Idaho populations based on the calculated values for individual GMU's above. We selected an extinction threshold of 10 fish and assumed no re-founding or temporal correlations in population size among sub-populations in this final modeling effort.

Results and Discussion

Population Trends

Historical snorkel counts

Trend counts in the historical mainstem St. Joe, Middle Fork Salmon, and Selway River snorkel sites all increased markedly during the mid- to late-1970s during a period following establishment of special regulations on much or all of their length (Figure 3). The sharp rise in the St. Joe River cutthroat trout population during this period was studied intensively and attributed to reductions in angler exploitation from a trophy fish regulation adopted in 1972 (Johnson and Bjornn 1978). The increase in cutthroat abundance on the Selway and Middle Fork Salmon Rivers is less well understood, but Ortmann (IDFG, unpublished data) observed that population increases on the latter water were less likely related to fishing regulation change than to natural factors.

Following three to five-fold increases in population numbers during the first 15 years of trend monitoring, populations in the two waters containing anadromous fish (Selway and Middle Fork Salmon Rivers) declined substantially during the late-1980's and early-1990's (Figure 3). In contrast, the St. Joe River population appeared to peak in size in 1995 and then declined.

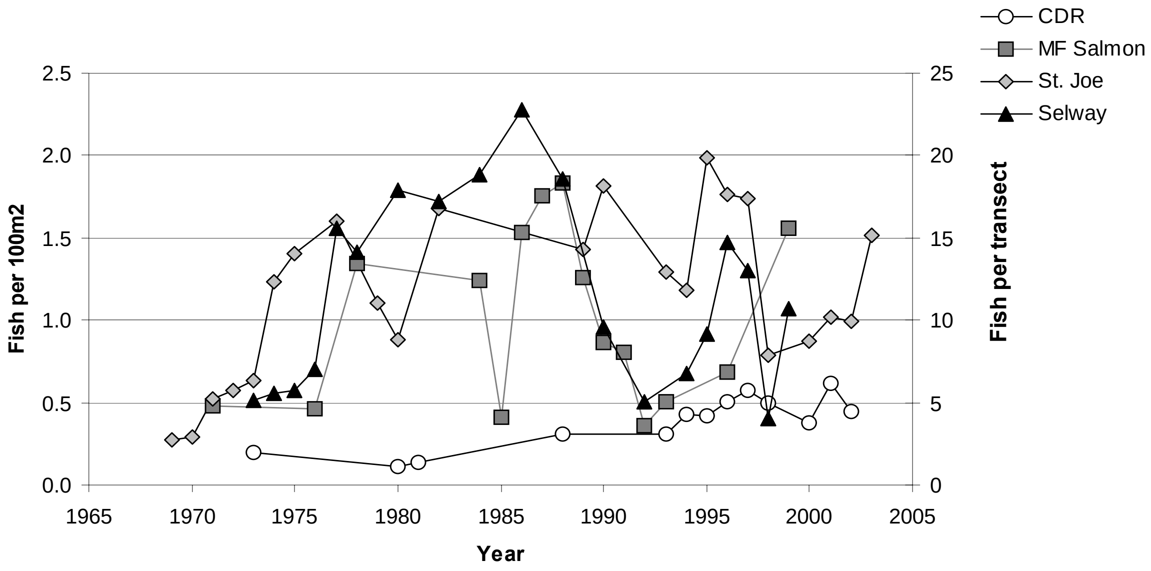

Figure 3. Trends in westslope cutthroat trout abundance (fish/100m2) determined by snorkeling in the St. Joe, Middle Fork Salmon, and Coeur d'Alene rivers, 1969-2000. Selway River data are available only in fish/transect (right scale).

Declines in all three of these streams occurred despite a continuation of mainstem special regulations and expansion of catch-and-release to most or all tributaries. The Selway and Middle Fork Salmon populations appear to have declined in near synchrony. All three populations appear to have increased sharply in the mid-1990s. Although data are more limited, cutthroat abundance in the Coeur d'Alene River also improved markedly during the late-1990s. An evaluation of possible reasons for the similarity of trends in these populations is outside the scope of this paper. However, it is worth noting that in general, drought conditions prevailed across Idaho from 1987 to 1994 (except 1993) with improved water conditions in subsequent years.

General Parr Monitoring counts

Examination of the GPM snorkel data suggests that most westslope cutthroat trout populations monitored within waters supporting anadromous species are either stable or increasing. Mean density (fish/100m2) in four of eight GMU's being monitored, including the Lochsa River, Lower Salmon River, South Fork Clearwater River, and South Fork Salmon River appeared to be flat, or nearly so (Figure 4). Mean density in the Middle Fork Salmon GPM sites appear to have declined since 1985, although data collected from the historical trend sites over a longer period do not demonstrate the same results. Conversely, westslope cutthroat populations in the Clearwater, Selway, and Upper Salmon rivers appear to have increased during the period from 1985 to 2000, as characterized by relatively steep trend line increases (Figure 4).

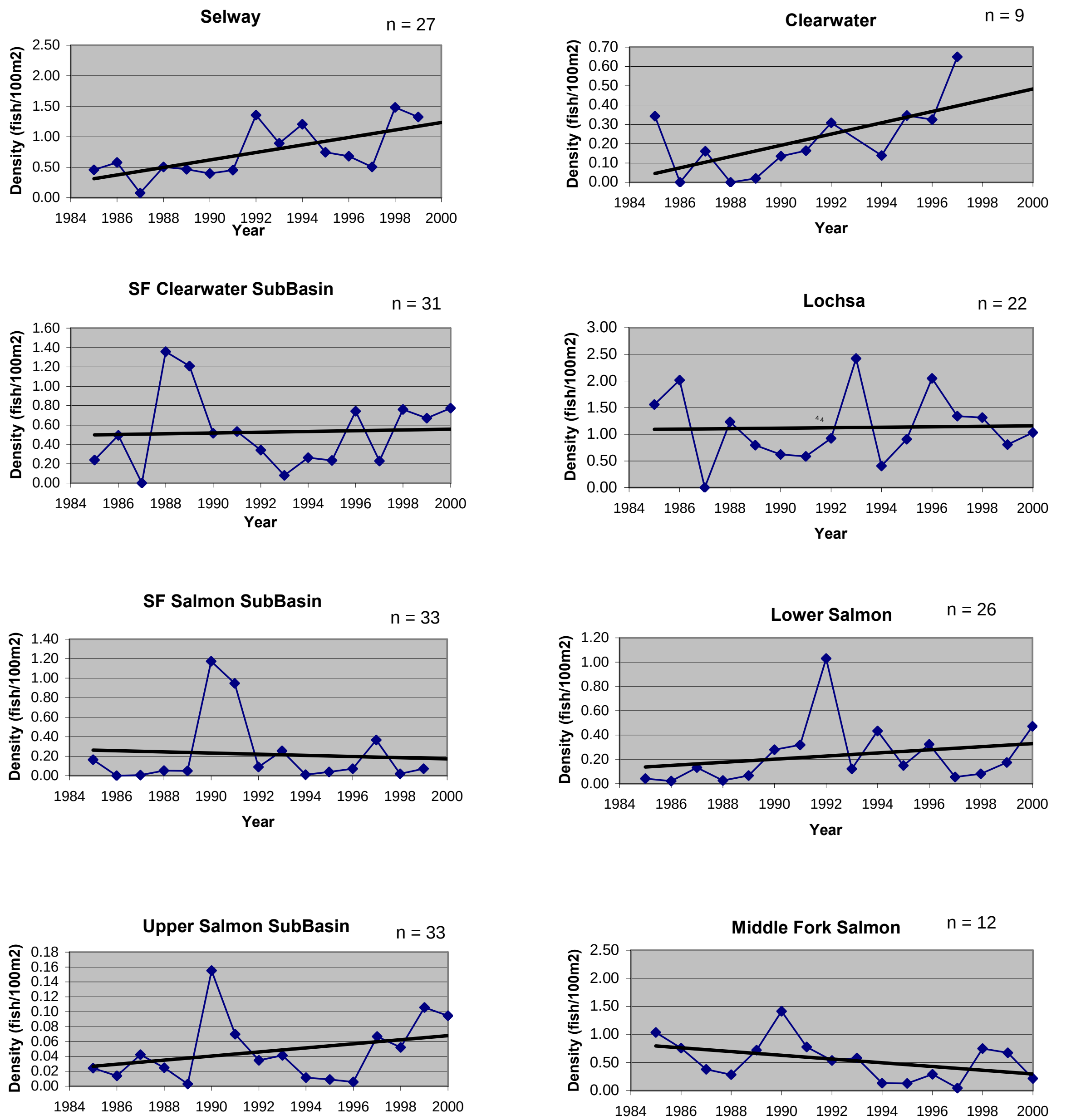

Figure 4. Trends in westslope cutthroat abundance (fish/100m2) determined by snorkeling at General Parr Monitoring (GMU) locations having 10 or more years of data during 1985-2000; n = numbers of individual count sites within the GMU.

Estimation of GMU Population Sizes

For the GMU's considered in this study, estimates of stream length occupied by westslope cutthroat trout range from 1,057 km for the South Fork Clearwater River to 3,351 km for the Middle Fork Salmon River (Table 1). Estimated mean linear density ranged from 5 to 149 fish/km on the South Fork Salmon and Selway rivers, respectively. With the exception of the mainstem historical snorkel counts, electronic data pertaining to fish densities on the St. Joe River were unavailable. However, historically available estimates of density on the St. Joe River have typically been high relative to other streams (Figure 3). We approximated what is likely a minimum number of fish present in the St. Joe River drainage assuming an average value of westslope abundance of 68 fish/km derived from all other drainages in this study (Table1). Estimates of westslope cutthroat trout numbers within the various GMU's ranged from 6,568 to 341,767 fish (Table 1) with a total combined estimate of approximately 1.2 million fish for the GMU's considered. Although space limitations preclude a detailed discussion of possible positive or negative biases in the above estimates, it is likely that total GMU population estimates for westslope cutthroat trout in this study (Table 1) were underestimated rather than overestimated.

Table 1. Approximate numbers of westslope cutthroat trout (WCT) present in geographic management areas (GMU's) based on linear "density" estimates (WCT/km) and number of km with WCT present.

Basin	Stream length[1] w/WCT (km)	Mean WCT/km	Total estimated WCT	No. of 3rd-4th order sub-basins	% GMU stream km in 3rd-4th order sub-basins	Estimated WCT in 3rd-4th order sub-basins	Mean populations size/sub-basin
Middle Fork Salmon River	3351	88	294,878	28	75%	221,158	7,899
St. Joe River	2185	68[2]	148,565	20	74%	109,938	5,497
Coeur d'Alene River	1446	15	21,058	13	74%	15,583	1,199
Selway River	2294	149	341,767	21	78%	266,578	12,694
Clearwater River	3507	40	139,504	33	79%	110,208	3,340
Lochsa River	1340	134	179,547	17	67%	120,297	7,076
South Fork Clearwater	1057	25	26,415	15	74%	19,547	1,303
South Fork Salmon	1314	5	6,568	13	84%	5,517	424

[1] As summarized by IDFG fishery management 2002 (Corsi unpublished data)
[2] Minimum estimate assuming average WCT/km across all drainages.

Assuming the total GMU-wide population estimates are within the realm of true abundance, the approximate mean sub-population sizes within the various GMU's ranged from about 400 to nearly 13,000 fish (Table 1). This estimate is admittedly a crude approximation. However, despite some limitations, these estimates provide a general range of sub-population sizes for Idaho westslope cutthroat trout populations for use when considering results from the extinction risk modeling below.

Extinction Risk Modeling

Estimated instantaneous rates of change (μ) for westslope cutthroat trout populations in 10 Idaho streams ranged from –0.059 to 0.1643 (Table 2). Based on the historical and GMP trend datasets, eight of 10 estimates were positive over the monitoring period implying increased population growth. Only two trend datasets including the Lochsa River and South Fork Salmon River counts, produced estimates of negative population growth.

Estimates of variance of instantaneous rates of change (σ^2) differed markedly among the four historical datasets and the shorter-term GPM trend sites (Table 2). Within the historical snorkeling datasets, estimates of σ^2 ranged from 0.07 to 0.37; estimates from the GPM database ranged from 0.50 to 4.03. With the exception of the highest estimate (4.03), the present estimates of variance around μ were similar to the range (0.07-1.02) reported by McIntyre and Rieman (1995) for seven westslope cutthroat trout populations in Idaho and Montana.

Table 2. Estimated mean (μ) and variance (σ^2) for instantaneous rates of change in westslope cutthroat trout populations calculated from snorkel counts in Idaho streams, 1969-2002.[1]

Basin	Dataset period	Years obs.	Sites counted	μ	σ^2
MFk Salmon River	1971-1999	15	12	0.0421	0.37
St. Joe River	1969-2002	20	27	0.0155	0.12
Coeur d'Alene River	1973-2002	13	29	0.0272	0.07
Selway River	1973-1999	19	27	0.0284	0.23
Clearwater River	1986-1998	10	9	0.054	1.05
Lower Salmon River	1985-2000	15	26	0.1643	1.28
Lochsa River	1985-2000	15	22	-0.0277	0.50
SFk Clearwater River	1985-2000	15	31	0.0777	0.74
SFk Salmon River	1986-2000	14	17	-0.059	4.03
Upper Salmon River	1985-2000	14	33	0.1004	0.89

[1] Calculated after Dennis et al. 1991

Predicted probabilities of persistence for 100 years in single local populations of westslope cutthroat trout in Idaho were strongly influenced by both the estimate of μ employed (observed versus an assumed equilibrium value of 0.0), and by the selection of an extinction threshold (Table 3). Not surprisingly, populations with low estimates of σ^2 (e.g., Coeur d'Alene River = 0.07 from Table 2) had a high probability of 100-year persistence, while populations with high variance (e.g. South Fork Salmon River = 4.03) had low probabilities of persistence regardless of the selected value for μ (Table 3). Persistence probabilities were relatively insensitive to changes in initial population size over the three population sizes modeled when holding all other factors constant. These results are similar to those reported by Rieman and McIntyre (1993) in their assessment of bull trout extinction risk.

Table 3. Estimated probabilities of persistence for single populations of Idaho westslope cutthroat trout given three different initial sizes. I alternately assumed extinction thresholds of 10 or 100 fish and also alternated estimates of μ and σ^2 and from existing trend data or an equilibrium value of μ (0.0) with observed σ^2.

	Pop size = 2500				Pop size = 5000				Pop size = 10,000			
	$\mu = $ 0.00		$\mu = $ observed		$\mu = $ 0.00		$\mu = $ observed		$\mu = $ 0.00		$\mu = $ observed	
	Threshold		Threshold		Threshold		Threshold		Threshold		Threshold	
Stream	10	100	10	100	10	100	10	100	10	100	10	100
MF Salmon	.637	.403	.827	.617	.694	.480	.866	.695	.746	.551	.898	.760
St. Joe	.899	.648	.951	.782	.947	.743	.971	.855	.991	.820	.984	.907
CDA	1.000	.779	.997	.952	1.000	.868	.999	.978	1.000	.935	1.000	.990
Selway	.752	.498	.886	.683	.808	.586	.918	.762	.856	.664	.942	.824
Clearwater	.410	.247	.576	.380	.456	.297	.624	.445	.500	.347	.668	.505
Lower Salmon	.376	.225	.774	.576	.419	.272	.813	.649	.460	.317	.846	.709
Lochsa	.565	.351	.428	.241	.621	.420	.483	.297	.672	.485	.535	.354
SF Clearwater	.479	.292	.751	.543	.530	.351	.794	.618	.578	.408	.830	.681
SF Salmon	.217	.127	.158	.090	.243	.155	.179	.110	.269	.181	.200	.131
Upper Salmon	.442	.267	.753	.550	.490	.322	.796	.623	.536	.375	.831	.686

If large numbers of local populations of westslope cutthroat trout in Idaho were believed to function in complete isolation within the range of three population sizes modeled (2,500 to 10,000 fish), then many would be assumed to be at risk of extinction within 100 years based on the results of Table 3. Isolated populations may indeed exist in some instances (e.g. South Fork Salmon) where the approximated sub-population size averaged less than one thousand individuals (Table 1) and westslope cutthroat trout are not widely distributed within the GMU (Thurow 1985). In addition, other large stream systems with less prominent westslope cutthroat populations than those considered in the present study (e.g., The St Maries River) may be areas for concern. However, given the widespread distribution of westslope cutthroat trout in many of the relatively pristine watersheds in central Idaho, and extensive movement patterns documented for fluvial populations (Bjornn and Mallet 1964; Hunt and Bjornn 1991), it is likely that many local sub-populations within the study area function as a classic metapopulation (Levins 1970) or a less traditional form often observed (Harrison 1991). In either event, an increased probability of overall persistence would be expected compared to the above estimates of persistence for single local populations (Harrison 1991; Doak and Mills 1994).

An assessment of the number of westslope cutthroat trout populations necessary to ensure a high probability of persistence in the absence of dispersal provides some perspective on extinction risk for such meta-populations. For populations ranging in initial size from 500 to 20,000 individuals, the number of sub-populations needed to maintain a 95% probability of at least one population persisting 100 years ranged from two to seven populations for the two simulations involving modest growth and equilibrium growth (Figure 5). In the case of a declining population experiencing high variance, the number of populations needed for 95% persistence ranged from eight to 18 populations, across the same initial population size range.

A major limitation of the PVA modeling approach used in this study is that in calculating extinction risk, the Dennis et al. (1991) model assumes that no density-dependence occurs. McFadden (1977) argued for the widespread reality of density-dependent processes in fish populations noting that the existence of such processes comprise the very core of fishery science. Assuming density-dependence actually occurs, Goodman (2002) observed that most combinations of reasonable parameter values in the Dennis et al. (1993) model will result in projections either trending to unrealistically high levels or to short-term extinction. Use of a positive growth value in the model will likely result in optimistic estimates of persistence, although results could not be biased past the predictions observed for equilibrium growth (Figure 5). Conversely, use of a negative growth value in the model will result in unduly pessimistic persistence predictions (Goodman 2002). Because the majority of available trend data for Idaho westslope cutthroat trout suggest a either positive population growth or equilibrium growth, the curve in Figure 5 based on equilibrium growth ($\mu = 0.0$) is probably the best point estimate. This curve suggests that, under the range of population sizes modeled (250-30,000), only three to nine sub-populations would be needed to ensure population persistence. Results of Table 1 suggest that the number of sub-populations present (3^{rd}-4^{th} order drainages) in many Idaho GMU's exceed these levels and they should therefore be adequate for persistence.

A very conservative approach to assessing westslope cutthroat extinction risk would be to consider the area *between* the curves for equilibrium and negative population growth as the guideline for assessing risk (Figure 5). As an example, for multiple sub-populations with initial sizes of 10,000, the number of sub-populations necessary to ensure 100 year persistence would be 4 to 9. For populations with initial sizes of 1,000 the number of populations needed would range from 7 to 15. Again, based on the rough estimates of sub-basin population sizes for various GMU's (Table 1), a sufficient number of populations appear available in most cases.

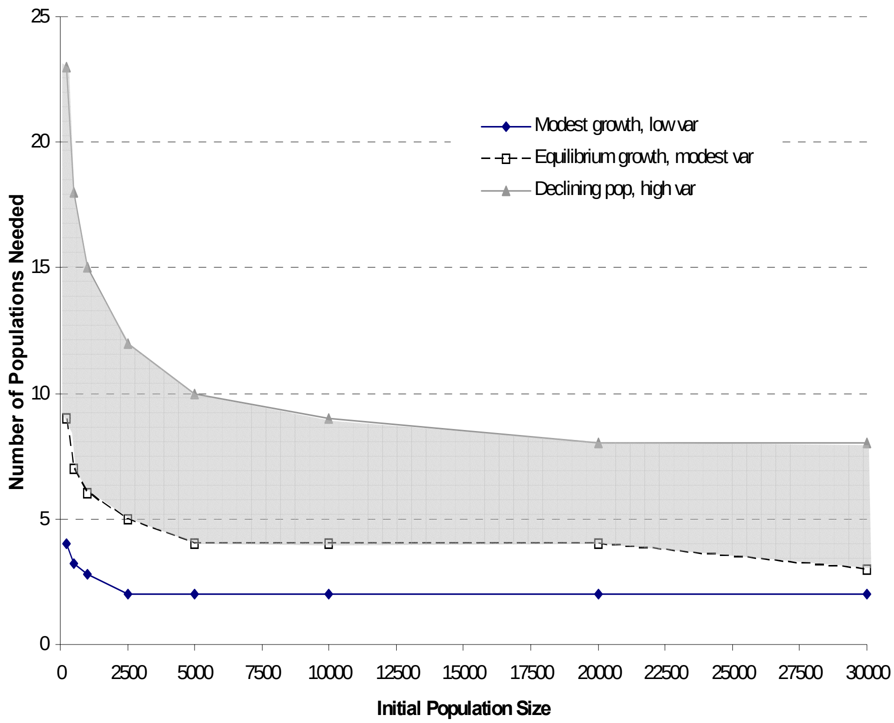

Figure 5. Estimated number of westslope cutthroat trout populations necessary to ensure a 0.95 probability of persistence for at least one population, given a range of likely sizes. Modest growth values from Middle Fork Salmon River (μ = 0.042, σ^2 = 0.37), equilibrium μ assumed to be 0.0 with moderate variances of 0.75, declining population μ from the SFk Salmon River (μ = -0.059) with high variance (1.28) from the Lower Salmon River. All populations assumed to be completely independent. Equilibrium growth value the best point estimate for most Idaho populations based on available trend data; shaded area a conservative estimate due to inability of Dennis et al (1993) model to consider density dependence (see text).

Although generalizations on the number of sub-populations needed for persistence in this study should only be viewed as approximations, it seems likely that they are quite conservative. The GMU population sizes developed to put the various extinction estimates into general perspective are likely underestimated given the use of snorkel counts and location of GPM sample sites. Perhaps the most compelling reason to suspect the persistence estimates produced by this study are conservative relates to sampling error likely involved in our estimation of population trends. The variance (σ^2) associated with point estimates of infinitesimal population growth rate (Table 2) assume no measurement error in the population trend data; i.e., 1) all variation in snorkel counts is due solely to population changes and 2) counts within the snorkel trend count zones reflect the stream-wide population trend perfectly. In reality, differences in personnel snorkeling skills, possible annual differences in fish movement, and a host of other factors are reflected in the snorkel count data. In past extinction assessments, sampling error associated with population trend data has turned out to be important, creating considerable negative bias in the persistence probabilities derived via the Dennis model (Rieman and McIntyre 1993; B. Rieman, USFS, personal communication).

Applying the model projections of Table 3 and Figure 5 directly to specific estimates of sub-population size is impossible; the requisite data are not available. Even if available, it is questionable whether such absolute extinction risk estimates would be rigorous enough (Ralls et al 2002). Instead, we have opted to develop some simple, generalized risk models that compare the relative extinction risk for various populations with a range of population size and growth rates characterized by available data. The use of such generalized PVA models to evaluate relative extinction risk can be quite useful when viewed as thought experiments (Ralls et al. 2002). In fact, it has been argued that use of such a simplistic modeling approach is preferable to more "realistic" spatial models that are often too poorly parameterized to be of much use (Doak and Mills 1994).

Conclusions

The dataset developed for assessing trend in this study is comprised of 301 individual sites where westslope cutthroat trout trends counts have been conducted via snorkeling over a 10 to 34 year period. Given the extensive monitoring period and the relatively broad dispersion of the snorkel monitoring sites used in this study, these data likely comprise the most extensive monitoring effort for a resident trout species ever conducted in America. Taken collectively, the data do not suggest that westslope cutthroat trout are declining in abundance within Idaho. Rather, the broad distribution of sites involved in both the historical sites (Figure 1) and the GPM dataset (Figure 2) and results of the trend analysis (Figures 3 and 4; Table 2) demonstrates that westslope cutthroat trout have maintained or increased their population abundance over a very large area within the state of Idaho during the past several decades.

Total estimates of westslope cutthroat trout numbers within the various GMU's ranged from 6,568 to 341,767 fish with a total estimate of approximately 1.2 million fish for all GMU's combined. Although estimates of precision for these estimates are not presented due to non-random sampling, consideration of possible sources of bias indicates that the above estimates are likely to be conservative.

Although estimates of population persistence for 100 years ranged from high to low for various individual local populations, the above study results suggest that numerous large sub-populations within most GMU's, available to interact within in a classic or less traditional metapopulation framework, would result a high ($\geq$95%) probability of persistence over 100 years in many instances.

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Effectiveness of Constructed Barriers at Protecting Apache Trout (*Oncorhynchus gilae apache*)

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ABSTRACT—Apache trout (*Oncorhynchus gilae apa*che) are a federally threatened salmonid endemic to the White Mountains of east-central Arizona. Nonnative salmonids can prey on, compete with and hybridize with Apache trout, and have thus been identified as a major threat to this species. Emplacement of fish migration barriers (primarily of gabion construction) on selected streams is one of the major recovery actions being used to isolate and protect upstream populations from nonnative salmonids; however, the effectiveness of this recovery action has not been evaluated. We evaluated the success of constructed barriers at preventing the upstream movement of nonnative salmonids. We also evaluated if barriers affected Apache trout population characteristics by examining condition and size structure above and below barriers. We examined historical survey data from eight streams following pesticide treatment and re-stocking of Apache trout, to determine if non-native salmonids reinvaded. Sixty-four percent of the barriers failed to isolate Apache trout populations. We also marked 1,436 salmonids downstream of barriers on six streams and subsequently electrofished upstream of the barriers to determine if marked salmonids had moved past barriers. We found two marked salmonids upstream of one barrier; no marked fish were found upstream of any other barriers. Failure of barriers to prevent upstream movement of nonnative salmonids was likely due to structural deterioration, design flaws, or angler transport. We suggest success might be improved if gabion barriers are filled with concrete or if solid concrete barriers are used. Barriers should be inspected biennially, repaired, or modified when necessary. We found little evidence that barriers negatively impacted population characteristics of Apache trout. Apache trout condition was higher above barriers in two of six streams, but no difference was found in any other streams. Apache trout were significantly smaller below barriers than above barriers suggesting downstream movement of fry, localized spawning.

Evaluating Single-Pass Catch as a Tool for Identifying Spatial Pattern in Fish Distribution

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Extended Abstract

One of the most critical issues currently facing wild trout managers is simply determining the distribution and relative abundance of trout, and evaluating how these parameters change through space and time. Because patterns may emerge at multiple spatial scales, a conservative approach incorporates a fine sampling grain, a large sampling fraction, and the maximum extent possible. As sampling fraction and extent increase, the application of high precision sampling techniques becomes prohibitively expensive. We assessed the efficacy of single-pass electrofishing, without blocknets, as a tool for collecting spatially continuous fish distribution data in headwater streams. Spatial patterns in abundance, sampling effort, and length-frequency distributions from single-pass sampling of coastal cutthroat trout (*Oncorhynchus clarki clarki)* were compared to data obtained from a more precise multiple-pass removal electrofishing method, with blocknets, in two mid-sized (500-1000 ha) forested watersheds in western Oregon.

Methods

After initial habitat assessment and classification of two streams (Blowout and Slide creeks), single-pass electrofishing was used to collect fish in all pools and cascades in each watershed. Subsequently, all cascades and every third pool (with a random start) were sampled using multiple-pass electrofishing, and fish abundance was estimated for each unit. A waiting period of 6 - 24 hours separated single- and multiple-pass sampling events in each habitat unit. If the waiting period was exceeded, units were discarded and replaced as follows: (a) if the unit was a pool, a new random draw was made from the next three available pools, or (b) if the unit was a cascade, sampling resumed at the next available cascade in the watershed. All fish > 70 mm that were collected during single-pass sampling were marked with a fin clip so that they could be identified during subsequent assessments. In Blowout Creek, fish received a combination of fin clips unique to the habitat unit from which they were collected. In Slide Creek, only the adipose fin was removed.

Results and Discussion

Capture probabilities for fish in individual habitat units ranged from 0.58 to 1.00 in Blowout Creek and 0.22 to 1.00 in Slide Creek, but differences among habitat units were not statistically significant ($P>0.05$) in either stream. The mean capture probability and coefficient of variation were 0.82 and 16% and 90 and 19%, for Blowout and Slide creeks, respectively. In contrast to capture probabilities, total catch from multiple-pass removal sampling was highly variable among habitat units. Mean number of coastal cutthroat trout captured was 7 (CV=113%) for Blowout Creek and 3 (CV=134%) for Slide Creek. Abundance estimates from the two electrofishing methods were positively correlated in both watersheds (r = 0.99 and 0.86). Differences between single-pass catch and catch from the first pass of the multiple-pass removal estimate were not statistically significant ($P > 0.05$) in either stream. Approximately 78% of the estimated population of cutthroat trout in Blowout Creek and 74% of the estimated population in Slide Creek were captured during the single-pass sample, but the effort expended was only , 7 and 10% of the total needed to make the population estimates.

Stream ecologists have been slow to recognize the role that scale may play in interpretation of observed phenomena (Fausch et al. 2002). For example, fisheries biologists commonly sample individual habitat units, or short, often arbitrarily defined lengths of a stream, and therefore, the scope of inference is generally limited to small spatial scales. However, when the scale of measurement of a variable changes, the variance of the sample also changes. This is especially applicable to the use of low-precision estimators over a large spatial extent. When grain size (sample unit) remains fixed, increasing extent results in increasing heterogeneity or variance among sample units (Wiens 1989). As variance among sample units increases, the value of precise estimates of the parameter of interest at the unit- or grain-scale declines because within-unit variance explains less of the total variation. Thus, there is an advantage to increasing the sampling fraction within the extent of the survey rather than the precision of estimate for individual sample units (Hankin 1984; Hankin and Reeves 1988).

We observed a substantial range in capture probabilities among sample units (i.e., pools and cascades); however, at the watershed scale, there was no trend in capture probability (i.e., upstream or downstream) in either stream. In addition, among-habitat-unit variation in abundance was much greater than variation in capture probabilities. Therefore, it appears that the extent of stream sampled in this study was sufficient to give an accurate depiction of relative abundance at the watershed scale. These results suggest that when compared to single-pass catch, multiple-pass removal procedures provide a more accurate estimate of coastal cutthroat trout abundance at the habitat-unit scale, but the multiple-pass method provided no additional information about the pattern of fish distribution. Because the effort expended to acquire the multiple-pass population estimates was at least seven times greater that required for the single-pass estimate of relative abundance, it appears that at the scale of intermediate sized watersheds, single-pass electrofishing is effective for detecting patterns of cutthroat trout abundance and investigating habitat relations at larger scales.

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Determining Ecologically Relevant Temperature Criteria for Salmonids: A Laboratory Approach

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ABSTRACT—Water temperature is one of the most fundamental environmental influences on fishes, particularly temperature-sensitive wild trout. However, thermal tolerances and optimal temperatures are unknown for many native North American salmonids. We have applied the Acclimated Chronic Exposure method to determine thermal optima and tolerances for bull trout *Salvelinus confluentus* and westslope cutthroat trout *Oncorhynchus clarki lewisi*, and to determine how these criteria may be influenced by competition from nonnative trout (rainbow trout *Oncorhynchus mykiss,* and brook trout *Salvelinus fontinalis*). The ACE method represents a more realistic measure of thermal tolerance than traditional methods (critical thermal maxima, incipient lethal temperature) because of slower acclimation times (1 °C/d) and long-term (60 d) exposure of test fish to elevated water temperatures while allowing simultaneous assessment of growth and survival. Our results indicate that both bull trout and westslope cutthroat trout have upper lethal and optimum growth temperatures in the lower range among North American salmonids, including other cutthroat trout subspecies. More detailed information on thermal criteria for wild trout will allow improved assessment of habitat suitability, species interactions, and response to climate change.

Colorado River Cutthroat *(Oncorhynchus clarki pleuriticus)* Habitat Restoration on the Green River Tributary Little Twin Creek

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ABSTRACT—Little Twin Creek would be an ideal spawning stream for Colorado River Cutthroat Trout inhabiting the Green River. However, salmonid spawning in general was rare due to decades of overgrazing and poor management practices. Joseph Urbani and Associates were hired to lead the restoration efforts on this creek in the fall of 2003. These efforts involved bed manipulation and the removal of many tons of fine sediment. During this process, gravels were exposed while pools and riffles were constructed. Creek passage was improved by removing some of the numerous beaver dams that blocked access to the upper section. Restoration efforts are being monitored through macro invertebrate inventories.

Declining Brown Trout in the Batten Kill

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ABSTRACT—The Batten Kill was previously considered a top blue-ribbon trout fishery in the Northeast. Stocking of brown trout (*Salmo trutta*) was discontinued in 1972 and a self–sustaining population has existed for at least a decade until the abundance of fish in all size classes began declining steadily. In response, a study team was formed to investigate potential factors that could contribute to the decline in fish numbers; e.g., habitat, water quality, contaminants, temperature, flows, nutrient enrichment, diseases, predation, forage, and conflicting recreational uses. Population modeling is a tool we used to identify events in the life cycle that impinge on population growth. Tentative indications are that the bottleneck in the population is affecting midsize trout, i.e., those ~150-200 mm (6 to 8") long. That pattern appears to possibly be associated with at least three of the factors from the Batten Kill Study Team list: declining habitat quality due to lack of cover in the stream, increasing activity of bird and mammal predators, and introduction of pathogens. Importantly, early indications do not implicate problems at the early stages of the trout life cycle, which might be associated with water pollution or siltation.

Minimizing Effects of Piscicides on Macroinvertebrates

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ABSTRACT—Great Basin National Park minimized effects of piscicides through fish distribution surveys that reduced area treated and monitoring macro invertebrate response to rotenone and antimycin. Fish distribution surveys found 3.1 miles of Strawberry Creek and 0.9 miles of Snake Creek would not require treatment. Rotenone was dispensed into Strawberry Creek at 5 ppm for one hour and 2 ppm for seven hours over two days. Antimycin was dispensed into Snake Creek averaging eight ppb for eight hours. Under rotenone, macronvertebrate abundance declined 85% (1762/m^2 to 263/m^2) at one-month post-treatment and taxa richness was reduced 95% at one-week post-treatment. Ephemeroptera, Plecoptera and Trichoptera (EPT) group abundance declined 99% (833/m^2 to 10/m^2). Except for one sample, abundance and Taxa richness has not exceeded pre-treatment levels after three years. Five species had not returned after one year and two species are still absent after three years. Under antimycin, total abundance declined 61% (1642/m^2 to 635/m^2) while EPT abundance declined 54% (766/m^2 to 353/m^2) one-month post-treatment. Taxa richness declined less than 30%. All but one species has returned after one-year. .Macroinvertebrate abundance increased 300% 9-months post-treatment. Providing non-treated areas, all missing species are still found in non-treated areas, and using antimycin minimized impacts on macroinvertebrates.

Natural Environmental Variability and Acid Sensitivity: What Drives Brook Trout and Blacknose Dace Population Density in Shenandoah National Park, VA?

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ABSTRACT—We performed bi-annual basinwide visual estimation technique fish surveys on Paine Run, a highly acid sensitive stream, and Staunton River, a moderately acid sensitive stream in Shenandoah National Park, VA between 1993 and 2003. We estimated population density, length, and weight for blacknose dace *Rhinichthys atratulus* and brook trout *Salvelinus fontinalis*. Population density estimates for both age-0 and adult (all fish older than age-0) brook trout were highly variable in both streams, but were nearly always higher in the Staunton River. Conversely, the population density of blacknose dace was nearly always higher in Paine Run. The average size adult brook trout was similar between streams, as was relative weight (W*r*) of adult brook trout >130 mm, however the average size and condition factor (K) of age 2+ blacknose dace was lower in Paine Run. High density of age-0 brook trout in the fall generally corresponded to high density of adult trout the following spring; however, there was no relationship between density of adult trout in fall and density of age-0 trout the following spring. Natural environmental variability and acid sensitivity appear to drive fish population density in these streams by affecting blacknose dace condition and age-0 trout survival.

Salmonid Restoration Using Streamside Incubators

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ABSTRACT—Trout Unlimited (TU) and the U.S. Forest Service (USFS) are using "old refrigerators" and "ice-chest coolers" as streamside incubators to restore native salmonid populations. The "old fridge" was successfully developed by Dr. Fred Eales, Flaming Gorge-Lower Green River Chapter TU, Rock Springs, Wyoming (WY) in 1987. This TU chapter alone has proven the technique during the last 15 years by hatching over 13 million eggs of twelve (12) different species and strains of salmonids. In 1998, “old friges,” were used on the Goshute Indian Reservation, Utah, to achieve a 92% hatching success of Bonneville cutthroat trout (BCT) from green eggs to swim-up fry, and a 92% hatch of 5,000 eyed-eggs of triploid rainbow to develop tribal recreational fisheries. In Central Utah, on Trout Creek, tributary to Strawberry Reservoir, the "old frige" had a 90% hatch success of 16,000+ green eggs of BCT. In Nevada, in the Lahontan Basin, within the Truckee River drainage, TU and the Pyramid Lake Paiute Tribe used two "old friges" to hatch 225,000 Lahontan cutthroat trout eyed-eggs in 1998. This was done in cooperation with U. S. Department of the Interior Secretary Bruce Babbitt and had a resulting 92% hatching success. Sec. Babbitt was in the western U.S. to endorse the use of the "old frige" for threatened and endangered salmonid species recovery in conjunction with stream habitat enhancement and land management plans implementation for native trout. The USFS & the Shoshone-Bannock Tribe, Idaho, are using the “frige" for salmon & steelhead in the Salmon River. This effort is used on the Salmon-Challis National Forest to recruit wild salmonids into the Salmon River, a tributary in the Columbia River Basin, and has a hatching success of 85% to 99% for both eyed and green eggs to swim-up fry. The use of the "old frige" and "coolers" represents another management "tool" that fisheries managers can use for replenishing salmonid populations for recreational fisheries as well as "jump starting" native trout in stream restoration programs.

Population Characteristics of Lake Trout in Lake McDonald, Glacier National Park: Implications for Removal

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ABSTRACT—Native bull trout *Salvelinus confluentus* have suffered a dramatic population decline since the establishment of nonnative lake trout *Salvelinus namaycush* in Lake McDonald, Glacier National Park (GNP). In an attempt to prevent further decline of this population, GNP is considering a lake trout removal program. This study was conducted to examine the population characteristics of lake trout and model the effects of varying exploitation on lake trout in Lake McDonald. Saggital otoliths were aged from 154 lake trout. The von Bertalanffy growth model was used to estimate theoretical maximum length (687 mm), growth coefficient (0.103), and time when length would theoretically equal 0 mm (-0.324). Growth in length was typically lower than lake trout in Yellowstone Lake, Wyoming. Model simulations for a population of 25,000 individuals indicated that lake trout abundance decreased as the minimum size of lake trout that could effectively be removed decreased. Additionally, an exploitation of 90% was needed to reduce the number of 500 mm and larger lake trout to zero at 20% natural mortality. These data illustrate that complete removal of lake trout in Lake McDonald is highly unlikely; however, moderate levels of exploitation (30-50%) could negatively impact the population.

Wild Fish Habitat Initiative: Technology Transfer Project

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ABSTRACT—Habitat degradation is one of the principal reasons for the listing of wild fish as "threatened" or "endangered" under the Federal Endangered Species Act and can exacerbate the detrimental effects of fish predators, exotic competitors, and diseases such as whirling disease. In addition, land values are diminished by habitat degradation and the subsequent loss of wild fish populations. In recent years, many fish habitat enhancement and restoration techniques have been implemented; project results, however, have not been shared widely and their efficacy is not well understood. The technology transfer portion of the Wild Fish Habitat Initiative seeks to augment the success of habitat restoration programs by featuring selected habitat restoration techniques, and by implementing a technology transfer program to share information on project results and to provide technical information to land owners and project managers. The technology transfer program includes online bibliographic and restoration manual resources, as well as a case histories database of restoration projects implemented in the Intermountain West.

Efficacy of Fish Screens on Irrigation Diversion Canals at Skalkaho Creek, Montana

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ABSTRACT—Wild Trout Guidelines - Problem statement, issue significance, objectives, findings, and conclusions should be relayed in 200 words or less. Post-spawn adult and downstream migrant juvenile westslope cutthroat trout (Oncorhynchus clarki lewisi) are entrained, become trapped, and die in the seven irrigation canals on Skalkaho Creek, a tributary of the Bitterroot River. We quantified entrainment rates into the canals using telemetry and trapping before (2003) and after (2004) installation of fish screens at three of the canals to provide private landowners and agency personnel with an in-depth evaluation of the value of fish screens. We also examined the efficacy of the screens in returning downstream migrants to the stream. No telemetered adults were entrained in 2003, but most were residents and therefore did not migrate past the canals. Entrainment of juveniles occurred at the farthest upstream canal in 2003. Almost all age-0 juveniles encountering the canal were entrained, as it diverted most of Skalkaho Creek during the peak of summer irrigation, concurrent with peak emergence and downstream movement of age-0 juveniles. Six telemetered adults were entrained in 2004 in unscreened canals and six entered screened diversions; all six were successfully bypassed back to the creek. The screens effectively precluded entrainment.

Watershed Restoration—A Southern New Jersey Brook Trout Population at Risk

James Gracie

ABSTRACT—Mason's Run, in Camden County New Jersey is the only stream that still supports a self-sustaining population of eastern brook trout in southern New Jersey. Early settlers removed vast acreages of forest cover to engage in agriculture more than two hundred years ago, rendering most streams incapable of supporting trout. The major mechanisms for this loss were sediment loadings and loss of base flows and shade, which naturally moderated flow and summer water temperatures. With the abandonment of farms in the 1940's many areas have grown back into forest cover mitigating these past impacts. At the same time, unprecedented land development for homes, road, and businesses has dealt another severe blow to streams. In some places, there are enough mitigating factors to permit the survival and propagation of trout.

Mason's run in Camden County New Jersey, flowing through a large (approximately 560 acre) tract of relatively undisturbed land in the borough of Pine Hill still hosts a self-sustaining population of eastern brook trout. The reach of stream that supports the trout population is about 900 feet long. Downstream of the trout habitat there are two ponds in series which warm the water to lethal levels for trout in summer. The discharges from these ponds create a warm water environment downstream of the ponds as well. At the headwaters of Mason's Run, storm water runoff for a road system has created an unstable reach of ephemeral channel, which has incised delivering huge quantities of sediment downstream. This reach continues to be unstable. The sediment being delivered from the eroding reach is limiting the habitat downstream in Mason's Run by creating unstable streambed interfering with spawning success of brook trout and severely limiting macroinvertebrate populations.

This paper describes the restoration of Mason's Run, which was a part of mitigation plan for impacts on wetlands and buffers of a golf course construction project. Two ponds were eliminated and replaced with a reconstructed stream; the upstream sediment source was eliminated by restoring the ephemeral reach using the natural channel design approach to restoration. In addition, a sand trap was installed upstream of the trout habitat to remove sediment which is still stored and continues to be transported after the restoration of the unstable reach upstream. By understanding the factors limiting trout reproduction and growth in the watershed, the restoration approach created an opportunity for a watershed-wide recovery of trout habitat. The trout population may be an aboriginal strain of *salvelinus fontinalis* and was certainly at risk because of the limited gene pool and limited habitat for its survival and propagation prior to the restoration work.

Genetic Characterization of New Jersey Wild Brook Trout *Salvelinus fontinalis* Populations and Management Implications

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ABSTRACT—The brook trout *Salvelinus fontinalis* is New Jersey's only native salmonid species. Habitat alterations and widespread supplementation with cultured salmonids over the last century have likely impacted the distribution and genetic characteristics of brook trout statewide. Over the past 35 years, NJDFW surveys have documented the occurrence of 130 reproducing populations, primarily in headwater streams located in the forested hills and mountains of northwestern New Jersey. The ancestral origin of these brook trout populations is unknown, and in this study, molecular genetics is being used to assess differences in 22 of these reproducing brook trout populations. The genetic variation within and among 19 allopatric populations, and 3 populations that occur in sympatry with brown trout *Salmo trutta* and rainbow trout *Oncorhynchus* mykiss, is being examined using microsatellite DNA technology. Nuclear DNA extracted from red blood cells, and amplified at 13 gene loci using PCR, is being analyzed using a genetic analyzer. Software to score, bin, and output allelic data is being used to shed light on the genetic origin of these populations. Genetic variability is considered important in maintaining the adaptive ability of this species and its long-term survival. If unique, ancestral brook trout populations can be identified then specific management practices and conservation strategies to conserve these "heritage" populations will be developed and implemented.

Creating a Sanctuary for Wild Steelhead Trout through Hatchery Operations

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ABSTRACT—The Deschutes River basin in north-central Oregon supports a wild population of threatened summer steelhead (*Oncorhynchus mykiss*). The basin has seen large increases in the number of out-of-basin stray hatchery steelhead in recent years. Since 1987, hatchery strays have accounted for over 50% of the total steelhead returns to the Warm Springs River, a major tributary of the Deschutes River. While the large numbers of stray hatchery steelhead have contributed to making the Deschutes River one of Oregon's premier summer steelhead fishing streams, the impact of hatchery strays on the wild steelhead population is a concern for fishery managers. Warm Springs National Fish Hatchery, located on the Warm Springs River, is cooperatively managed with the Confederated Tribes of the Warm Springs Reservation of Oregon to produce spring Chinook salmon (*O. tshawytscha*) for harvest while protecting the indigenous fish populations in the river. To preserve the genetic integrity of wild steelhead populations, the hatchery is operated to allow only wild, unmarked steelhead upriver into the major steelhead spawning areas. The management and operation of the hatchery since its inception has created the only wild steelhead sanctuary in the Deschutes River basin.

Introduction

Fishery managers often use hatcheries as a tool for enhancement, mitigation, or supplementation of depleted fisheries resources. Hatchery programs, however, are often criticized for their effect on wild fish populations. In many instances, this negative criticism is warranted and hatchery programs can result in undesired ecological consequences to wild fish populations (Marnell 1986; White et al. 1995; Northwest Power Planning Council 1999). For salmon and steelhead hatchery programs in the Pacific Northwest, recent independent reviews have suggested management changes and reform measures to reduce the negative impacts of hatchery programs on wild fish populations (Hatchery Scientific Review Group 2000; Williams et al. 2003). In particular, the effect of naturally spawning hatchery fish on wild populations is receiving increased attention. In this paper, we look at the effect of stray, out-of-basin hatchery fish in the Deschutes River and how the unique management and operation of a hatchery facility has created a sanctuary for wild summer steelhead trout (anadromous form of *Oncorhynchus mykiss*).

Site Description

The Deschutes River originates on the east slope of the Cascade mountain range, flows north through central Oregon, and enters the Columbia River at river kilometer (rkm) 330. Summer steelhead historically were found in the main-stem of the Deschutes River up to rkm 214. The development of the Pelton/Round Butte hydroelectric project, a series of three dams completed between 1958 and 1964, limited the natural production of anadromous salmonids to the main-stem

Deschutes River and tributaries below Pelton Dam at rkm 166 (Oregon Department of Fish and Wildlife (ODFW) 1997). Steelhead in the Deschutes River basin are part of the mid-Columbia River Evolutionary Significant Unit that was listed as a threatened species by NOAA-Fisheries in 1999.

The Warm Springs River is the major westside tributary of the lower Deschutes River. The river flows entirely within the Warm Springs Indian Reservation and enters the Deschutes River at rkm 135. Warm Springs National Fish Hatchery (NFH) is located at rkm 16 of the Warm Springs River (Figure 1). A barrier dam, located adjacent to the hatchery blocks all upstream migrating fish and diverts them into a fish ladder. Depending on hatchery operational needs, fish can pass upstream through the fish ladder or be diverted to hatchery holding ponds. Approximately 111 rkm of stream habitat is accessible to anadromous salmonids above the hatchery barrier dam (Cates 1992).

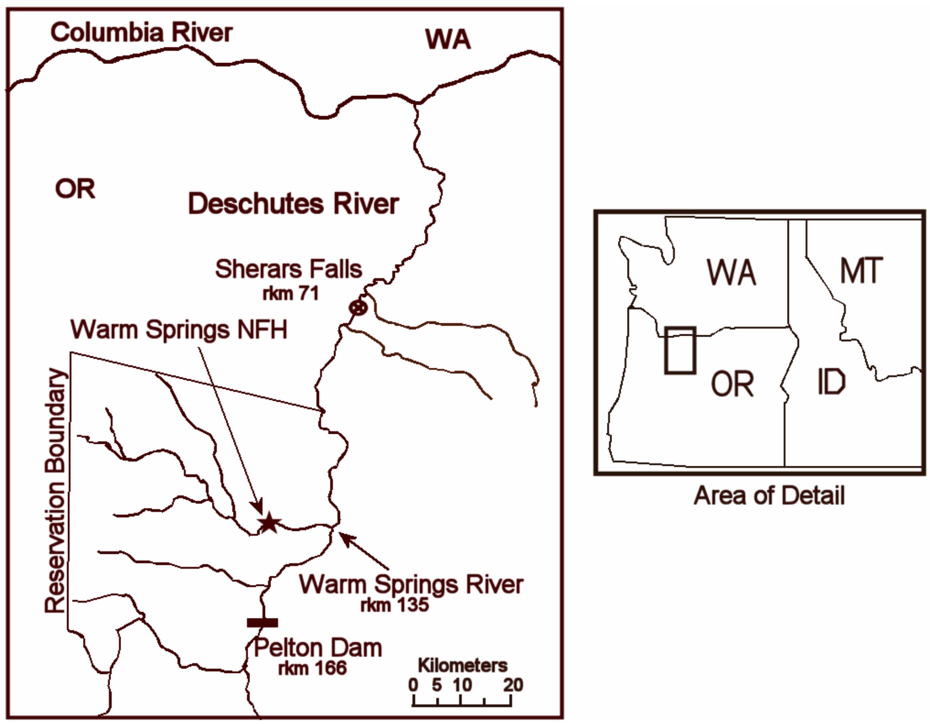

Figure 1. Map of the lower Deschutes River basin

History and Operation of the Hatchery

Warm Springs NFH was authorized by Congress in 1966 in response to a request from the Confederated Tribes of the Warm Springs Reservation of Oregon (Tribes) to establish a hatchery on Reservation land. The original purpose of the hatchery was to increase harvest opportunities of spring Chinook salmon (*O. tshawytscha*), summer steelhead, and trout (resident form of *O. mykiss*) in the Deschutes River and Reservation waters (Cates 1992). The hatchery, managed by the U. S. Fish and Wildlife Service in cooperation with the Tribes, became fully operational in 1978. The steelhead program was terminated in 1981 due to disease problems in the hatchery and the physical limitations of rearing 2-year-old smolts. Shifting priorities for the co-managers has resulted in the curtailment of resident trout production. Currently, the focus of the hatchery is on providing spring Chinook salmon for harvest in Tribal and sport fisheries in the Deschutes River. Olson et al. (1995) provide a detailed review of the spring Chinook salmon program.

Since the inception of the hatchery, federal, tribal, and state governments have worked together to develop a hatchery operational plan that minimizes the effects of hatchery operations on wild fish populations. In developing and updating the operational plan, the co-managers recognized the importance of wild steelhead populations in the Warm Springs River. When the hatchery steelhead program ended in 1981, a decision was made to try to limit the effect of hatchery steelhead on the wild fish populations in the Warm Springs River. Since any hatchery steelhead entering the Warm Springs River are straying from their hatchery release location, the operational plan was updated in 1984 to specifically exclude these strays from the spawning grounds upstream of the hatchery. During the steelhead spawning migration in the Warm Springs River, generally between February and May, all fish passing upstream through the fish ladder are diverted into holding ponds at the hatchery. Hatchery personnel hand sort the fish and pass wild, unmarked steelhead upstream of the fish ladder while hatchery steelhead, identified by marks applied at a hatchery prior to juvenile release, are removed from the stream and distributed to the to the Tribes for food. Prior to distribution to the Tribes, hatchery steelhead are checked for the presence of a coded-wire tag in the snout to determine their hatchery of origin. Coded-wire tags are small (<1.5 mm) identification tags that are implanted into juvenile hatchery steelhead prior to release and used to evaluate hatchery programs.

Steelhead in the Deschutes River Basin

Juvenile summer steelhead in the Deschutes River basin spend between one and four years rearing in freshwater before smolting and migrating downstream to the ocean (Northwest Power and Conservation Council 2004). After spending one to two years in the ocean, steelhead migrate back to freshwater and enter the Deschutes River as early as June and continue to enter the system throughout the summer and fall. Returning adults over-winter in the main-stem Deschutes River before moving onto the spawning grounds in the following spring. Based on limited spawning ground surveys in the main-stem and tributaries, main-stem spawning is believed to account for between 30% and 60% of the natural production in the basin (ODFW 1997). Spawning in eastside tributaries and lower sections of the main-stem generally occurs between January and April. Spawning in westside tributaries, such as the Warm Springs River, can begin as early as February, with peak spawning usually occurring in mid-April and continuing into May (Olson et al. 1995). Round Butte Hatchery, located at the hydroelectric project, is the only hatchery in the Deschutes River basin that currently produces summer steelhead. The hatchery, operated by the state of Oregon as part of a mitigation program for the hydroelectric project, annually releases around 160,000 summer steelhead smolts into the Deschutes River.

Reliable estimates of the number of adult steelhead entering the mouth of the Deschutes River are unavailable. A fish trap operated by ODFW, located at Sherars Falls on the Deschutes River (rkm 71), is used to sample steelhead as they pass upstream. Since the fish trap captures only a portion of the steelhead passing upstream, a Peterson mark-recapture method, with fish recaptured at

Pelton Dam and Warms Springs NFH, is used to estimate the total steelhead population. Fish are classified as either wild, Round Butte Hatchery, or stray (out-of-basin) hatchery steelhead based on fin marks. Sherars Falls steelhead numbers in this paper are derived from unpublished ODFW-Mid Columbia Fish District mark-recapture estimates.

The average number of wild and Round Butte Hatchery steelhead passing the falls between 1979 and 2002 was 5,030 (SD=2,769) and 4,959 (SD=2,571) adults, respectively. Large numbers of stray hatchery steelhead began passing the falls in the early 1980's, with an even more pronounced increase in numbers beginning in 1995 (Figure 2). Between 1995 and 2002, stray steelhead accounted for an average of 62% (SD=10%) of the total number of adult steelhead passing upstream of Sherars Falls. A large number of wild and hatchery steelhead migrating to other streams in the Columbia River basin enter the lower sections of the Deschutes River for a period of time before exiting back out to the main-stem Columbia River and continuing their migration to their natal streams for spawning (ODFW 1997). Based on recoveries of tags applied to stray hatchery fish and a radio-telemetry study, an estimated 50% of the stray hatchery steelhead passing upstream of Sherars Falls eventually exit the Deschutes River (Rod French, ODFW, personal communication). Since the origin of wild fish cannot be determined without genetic analyses, the number of stray wild fish that migrate up and down the river is unknown.

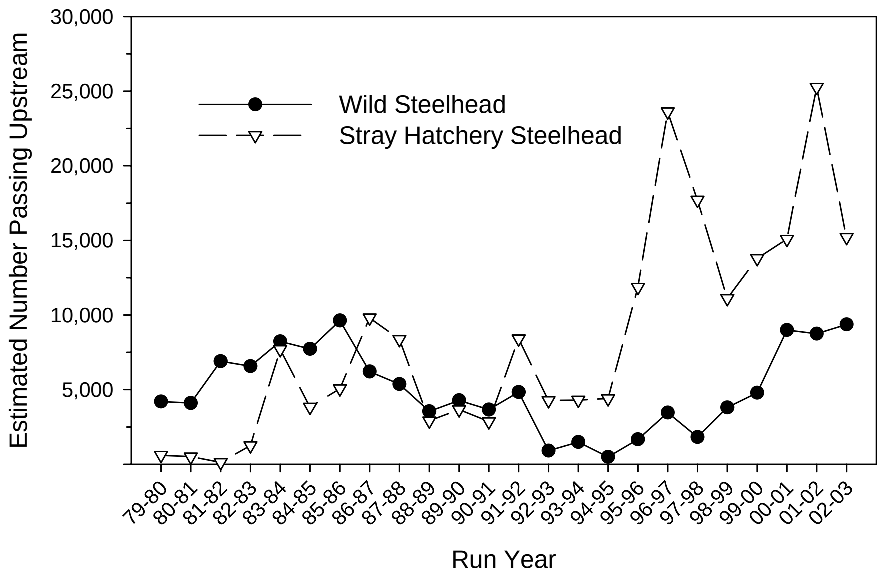

Figure 2. Peterson mark-recapture estimates of the number of steelhead passing upstream of Sherars Falls (ODFW unpublished data). Round Butte Hatchery fish are not included in this figure.

While 50% of the stray hatchery steelhead may eventually leave the basin prior to the spawning period, the large overall number of strays in recent years means that in many years the number remaining can equal or exceed the number of wild steelhead in the basin. The reasons for the large number of stray steelhead migrating up and remaining in the Deschutes River are unknown. Fish transportation operations, in which a proportion of juvenile smolts are artificially transported around main-stem Columbia and Snake river dams, may influence the straying rate of returning adults (Olson et al. 1995; Quinn 1997).

Some of the stray hatchery steelhead that remain in the Deschutes River move onto the wild steelhead spawning grounds. Based on spawning surveys conducted by ODFW on Buckhollow and Bakeoven creeks, major eastside tributaries that enter the Deschutes River at rkm 68 and 84 respectively, hatchery steelhead accounted for a yearly average of 42% (SD=25%) of the total number of steelhead on the spawning grounds between 1991 and 2003 (ODFW unpublished data). Shitike Creek, a westside tributary entering the Deschutes River at rkm 155 just downriver of Pelton Dam, also has stray hatchery fish moving onto the spawning grounds. Between 2001 and 2003, out-of-basin stray hatchery steelhead have accounted for an average of 28% (SD=7%) of the adult steelhead trapped at a weir located near the mouth of the creek (Confederated Tribes of the Warm Springs Reservation of Oregon, unpublished data).

Warm Springs River

The only tributary in the Deschutes River basin where stray hatchery steelhead are actively excluded from the wild steelhead population is the Warm Springs River. If strays were not excluded, the steelhead population in the Warm Springs River would have been heavily influenced by hatchery steelhead in recent years. The number of stray hatchery steelhead trapped and removed at the barrier dam at Warm Springs NFH increased substantially in 1987 (Figure 3). Between 1980 and 1986, stray hatchery steelhead accounted for a yearly average of 13% (SD=5%) of the total steelhead in the Warm Springs River. Between 1987 and 2003, an average of 51% (SD=10%) of the yearly steelhead run was composed of stray hatchery steelhead. The timing of upstream migration differed between wild and stray hatchery steelhead. The median day of migration to the barrier dam for stray hatchery steelhead was 14 days (SD=7 days) earlier than for wild steelhead.

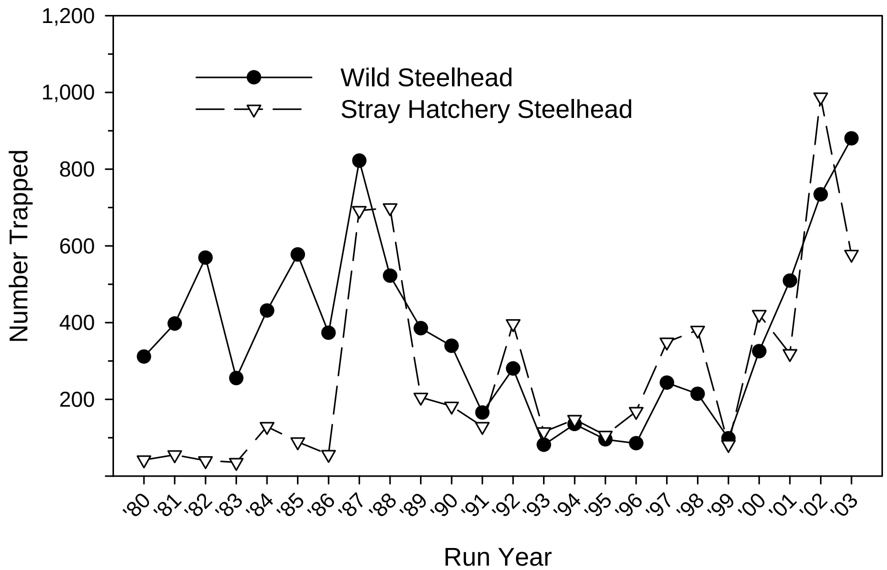

Figure 3. Number of steelhead trapped at the barrier dam at Warm Springs NFH (rkm 16).

Currently, the only way to determine the origin of stray hatchery steelhead in the Warm Springs River is to rely on the recovery of coded-wire tags. Analysis of stray steelhead is complicated by the fact that most hatcheries in the Columbia River basin do not coded-wire tag all of their juvenile steelhead releases. For example, in 2003 a total of 6.1 million juvenile steelhead were released from hatcheries in the Columbia River basin above Bonneville Dam (rkm 235). Of this total, only around 10% were coded-wire tagged (RMIS Database). To determine the straying rate of fish released from hatcheries that coded-wire tag at least a proportion of their juvenile steelhead releases, an expanded recovery number is estimated. The expanded recovery number is calculated based on the ratio of the number of coded-wire tagged fish released from each hatchery to the total number of fish released from that hatchery.

Between 1987 and 2002, expanded coded-wire tag estimates could account for 37% of the stray hatchery steelhead in the Warm Springs River. Of the strays that could be accounted for, most came from hatcheries or release locations in the Grande Ronde, Imnaha, Wallowa and other rivers in the Snake River basin (Figure 4). These rivers are over 450 rkm upriver from the confluence of the Deschutes and Columbia rivers. Since the origin of over 60% of the strays cannot be accounted for based on expanded coded-wire tag recoveries, a complete analysis of the straying phenomenon in the Warm Springs and Deschutes rivers cannot be completed. Strays from hatcheries that do not coded-wire tag any of their releases may be a source of a large number of strays trapped at Warm Springs NFH. In addition, although most hatchery steelhead are externally marked with an adipose fin-clip, making them easily recognizable to hatchery staff who are sorting fish, some fish are released without an adipose fin-clip as part of restoration efforts in the Upper Columbia and Snake rivers. For example, over 2 million non-adipose clipped juvenile steelhead were released from hatcheries in the Snake River basin in 2003 (U.S. Fish and Wildlife Service, unpublished data). If fish have no easily recognizable external marks and they do stray into the Warm Springs River they could be misidentified by hatchery staff as wild fish and be passed upstream into the spawning grounds.

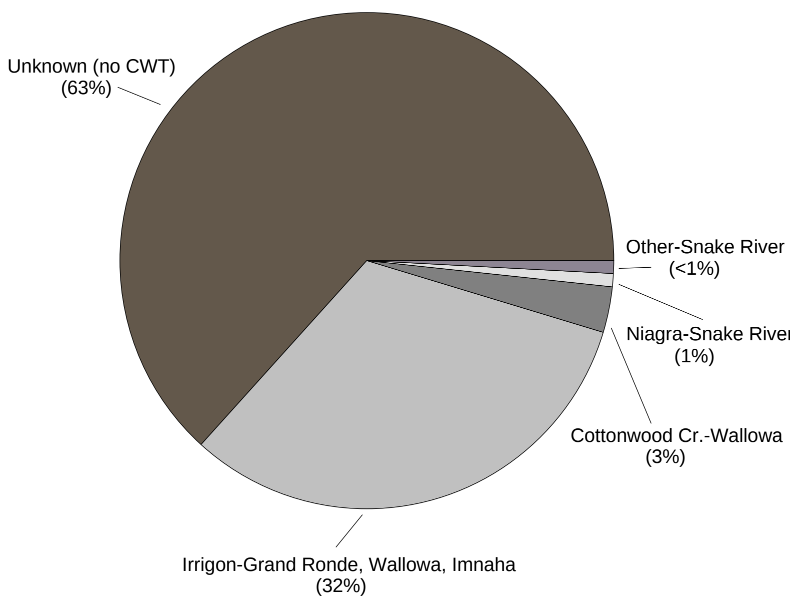

Figure 4. Origin of stray hatchery steelhead (n=4,910) at Warm Springs NFH 1987-2002 based on expanded coded-wire tag recoveries. Hatchery and release river are listed.

Impact of Stray Steelhead

The Deschutes River is a popular summer steelhead fishing stream for sport and tribal fisheries (ODFW 1997). A large portion of the sport fishery for steelhead occurs from the mouth of the river up to Sherars Falls and a tribal dipnet fishery is primarily focused on the area just below the falls. In 1979, in an effort to protect wild steelhead populations, sport harvest of summer steelhead was limited to hatchery fish. Sport anglers are allowed to keep adipose clipped hatchery steelhead, regardless of the hatchery of origin. The tribal dipnet fishery is regulated by the Tribes and harvest of a limited number of wild summer steelhead is allowed during years when wild steelhead populations are abundant. While Round Butte Hatchery produces steelhead specifically for harvest in the Deschutes River, stray out-of-basin hatchery steelhead make up a large component of the sport harvest. Based on a statistical creel survey, between 1987 and 1995 a yearly average of 1,907 (SD=590) hatchery steelhead were harvested in the sport fishery below Sherars Falls. During this time, stray hatchery steelhead accounted for an average of 83% (SD=7%) of the total sport harvest (ODFW 1997).

While stray hatchery steelhead are an important and valuable component of the Deschutes River sport fishery, the potential impact of the strays on the wild steelhead population is a major concern for fishery managers (Northwest Power and Conservation Council 2004). Fish straying from one basin to another have the potential to introduce diseases that are not endemic to the receiving basin. *Myxobolus cerebralis*, the causative agent of whirling disease in salmonids, has been shown to infect juvenile hatchery steelhead held at acclimation sites in the Wallowa and Imnaha rivers in the Snake River basin (Sollid et al. 2004). While whirling disease does not appear to be established in the Deschutes River basin, the presence of *M. cerebralis* has been detected in adult stray hatchery steelhead sampled at Warm Springs NFH since 1987. In 2003, 81 stray hatchery steelhead collected at Warm Springs NFH were tested and 15 were found to be infected with *M. cerebralis* (U.S. Fish and Wildlife Service, Lower Columbia River Fish Health Lab, unpublished data). All of the infected adults in 2003 were released as juveniles from acclimation sites in the Wallowa River. While the adults do not exhibit clinical signs of the disease, if they die in the stream they could potentially release myxospores into the water column. The removal of stray hatchery steelhead from the Warm Springs River reduces the likelihood of whirling disease or other non-endemic diseases being introduced into the drainage. Given the large number of strays that are in the Deschutes River, the potential for introduction of non-endemic diseases to areas downstream of Pelton Dam on the Deschutes River and downstream of Warm Spring National Fish Hatchery on the Warm Springs River is a concern and needs to be evaluated.

The impact of stray hatchery steelhead on the genetic integrity and productivity of wild steelhead populations in the Deschutes River is not known. Chilcote (2003) used data from the Deschutes River steelhead population as part of his analysis of mixed spawning populations of wild and hatchery steelhead. In that analysis he found a reduced level of productivity in populations that had a higher proportion of hatchery fish on the spawning grounds. Other studies have also described reduced productivity in mixed hatchery and wild steelhead populations (Chilcote et al. 1986; McLean et al. 2003). The actual mechanisms for the reduced productivity are not known, but the incorporation of genetic material from out-of-basin fish into the Deschutes River stock may reduce the ability of the wild stock to respond to environmental extremes (Northwest Power and Conservation Council 2004). Wild steelhead are locally adapted to the environmental conditions in the Deschutes River. Steelhead reared in hatcheries in the Snake River basin do not have these local adaptations and therefore may have reduced reproductive success when spawning in the Deschutes River. If hybridization between wild and stray hatchery steelhead occurs, introduction of non-locally adapted traits may reduce the overall reproductive success of the wild population. For example, the difference in timing of migration to the barrier dam on the Warm Springs River may indicate a difference in spawn timing between wild and stray hatchery steelhead. In areas of the Deschutes River basin where wild and stray hatchery steelhead are intermingled, some level of hybridization has likely occurred. McLean et al. (2003) suggested that altered timing of reproduction resulting from hybridization of wild and hatchery stocks could lead to a reduction in productivity.

Conclusion

The removal of stray hatchery steelhead from the Warm Springs River is an example of how the operation and management of a hatchery facility can play a role in the conservation of wild fish populations. The hatchery program has limited the potential mixing of wild and stray hatchery steelhead stocks and likely preserved the biological and genetic integrity of the wild steelhead population in the Warm Springs River. As such, the Warm Springs River may serve as a useful “control” stream for further investigations into the effects of stray hatchery steelhead on wild steelhead populations in the Deschutes River. We are currently developing plans to use mixed-stock genetic analyses to determine the origin of non-coded-wire tagged fish in the Warm Springs River, but the costs involved make it unlikely that this technique can be used on a basin-wide scale. A comprehensive marking and coded-wire tagging program for all hatcheries in the Columbia River basin will allow fishery managers to more effectively monitor and evaluate the straying problem in the Deschutes River.

Acknowledgements

Policy and biological support staff from the Confederated Tribes of the Warm Springs Reservation of Oregon have been leaders for the conservation of wild fish in the Warm Springs River. We thank on-the-ground work by U. S. Fish and Wildlife Service staff from Warm Springs National Fish Hatchery, the Lower Columbia River Fish Health Lab, and the Columbia River Fisheries Program Office, as well as policy support from our Regional Office. Rod French of the Oregon Department of Fish and Wildlife provided helpful information on steelhead populations in the Deschutes River and Jen Stone of the U. S. Fish and Wildlife Service provided an insightful review of this paper.

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Catch and Release Runoff to Cool the Watershed

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ABSTRACT—Cooling a watershed requires restoring natural processes that were in place for centuries prior to human intervention. The grazing, timbering, mining, and irrigated agriculture industries of the West have disrupted the natural processes. Unaided recovery would take centuries even if mankind did no further harm. Managing recovery involves catching runoff and releasing the water on an assigned portion of the watershed. The release system, a nominal "irrigation" system, is designed to assure that the water will evaporate (cooling) or infiltrate. The released water can be caught again further downstream and re-released. It is more valuable than trout.

A group of sites sized to catch and release a total of 10 AF per day would have a daily environmental value received of $216,630 to $284,420 depending on site evaporation to infiltration ratio. A hundred day season would be worth $21.6 million. The impact on neighboring areas would be worth an additional $20.7 million per season to them. Every mile of stream should be evaluated for possible implementation.

Influence of Fish Origin and Stream Discharge on Movements of Coastal Cutthroat Trout in a Headwater Stream

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Extended Abstract

Headwater streams on the western slope of the Cascade Mountains represent dynamic environments subjected to frequent natural perturbations. These streams account for a majority of stream length in forested areas and are easily altered by management practices (Chamberlin et al. 1991). Most studies of stream fish movement and habitat use involve spatially discontinuous sampling during discrete time intervals (Fausch et al. 2002). Although results may accurately depict localized phenomena, ecological patterns acting across multiple scales cannot be discovered (Levins 1992). Electrofishing censuses of 40 randomly selected headwater basins in western Oregon has suggested that populations of coastal cutthroat trout exhibit an aggregated spatial pattern at a variety of spatial scales (Gresswell et al. 2001). Subsequent continuous spatial sampling of the South Fork Hinkle Creek watershed documented a non-random, aggregated pattern of relative fish abundance in that system. In order to understand effects of variable stream discharge on spatial and temporal variation in relative abundance of coastal cutthroat trout, constant monitoring of tagged individuals is being conducted in contiguous sections of South Fork Hinkle Creek that exhibit diverse abundance patterns.

Methods

The South Fork of Hinkle Creek is a 3rd-order tributary of Calapooya Creek located in the Umpqua River basin in southwestern Oregon. The watershed is about 1100 ha and contains 7 km of fish-bearing stream with an average active channel width of 4 m. Fish species include anadromous steelhead (*Oncorhynchus mykiss*), resident sculpin (*Cottus* spp.) and potamodromous coastal cutthroat trout (*O. clarki clarki*). The watershed is located primarily in a second-growth Douglas-fir forest that is managed for industrial timber production.

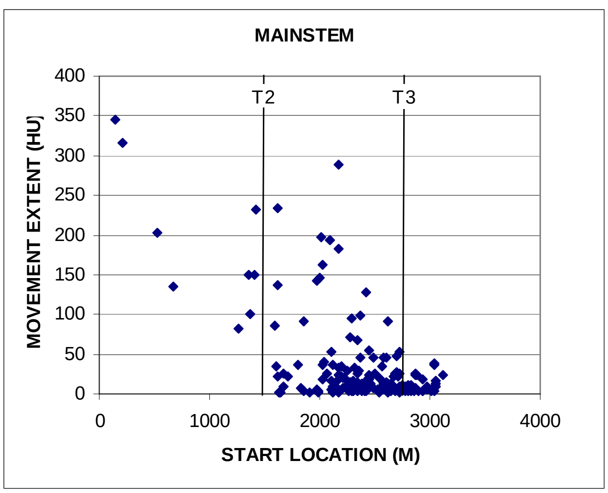
A total of 17 mainstem and 6 tributary habitat patches were identified during a watershed-scale electrofishing census of coastal cutthroat trout. Distribution patterns were used to identify habitat patches with high and low relative fish abundance. Habitat patches ranged in size from 30 m to 230 m and consisted of multiple channel units (i.e., pool, riffle, and cascade). A total of 296 coastal cutthroat trout ≥ 100 mm (fork length) were marked with 23-mm half-duplex PIT-tags and continuously monitored using data-logging PIT-tag readers.

In addition to 7 antennas located at tributary junctions, 24 additional stationary PIT-tag antennas were installed to completely encompass the habitat patches. Antennas were positioned perpendicular to stream flow and located in high-velocity habitats to minimize multiple PIT-tag readings related to fish holding behavior. Censuses of the study area using mobile PIT-tag antennas were conducted about every 1.5 months, and basin-wide censuses occurred seasonally (i.e., every 3 months). Stage-logging capacitance rods were installed at tributary junctions, and temperature loggers were located at 6 points in the study area.

Results and Discussion

From October 13, 2003 through June 1, 2004, continuous monitoring with PIT-tag readers and data loggers was achieved 90% of the time. Approximately 87% (116/133) of PIT-tagged fish that were originally tagged in the intensively monitored section were relocated by mobile and stationary antennas at least once. Fifteen percent (6/41) of fish from downstream origin and 7% (3/44) of fish from upstream origin immigrated into the intensively monitored section. Median extent of movement (i.e., difference between most upstream and downstream locations) and variation in the extent of movement were significantly different between fish of main stem and tributary origin (Mann-Whitney U-test $P < 0.01$; modified Levine Test for Equal Variance $P < 0.01$). In addition, differences in the median extent of movement and variance for fish originating below and above Tributary 2 were statistically significant (Mann-Whitney U-test $P < 0.01$; modified Levine Test for Equal Variance $P < 0.01$). Two fish tagged in Tributary 2 during the spawning season subsequently moved > 190 habitat units and were detected in the mainstem South Fork of Hinkle Creek (Figure 1).

Most coastal cutthroat trout moved during periods of low to moderate discharge levels (Figure 2). Approximately 57% (270/452) of longer distance “between-habitat patch” movements occurred at moderate stage heights, and 55% (353/640) of shorter distance “within-habitat patch” movements occurred during periods of low stage height. Sixty-one percent (279/457) of stationary behavior events (i.e., maintaining position within the detection field of an antenna for a minimum of 15 minutes) occurred during moderate stage levels. There was a two-fold increase in the median duration of stationary behavior events during times of high stage height (median =3.8 h) as compared to similar events at moderate (median = 1.6 h) or low (median = 1.9 h) stage heights. Movements from mainstem habitats to tributaries increased during periods of high stage height.



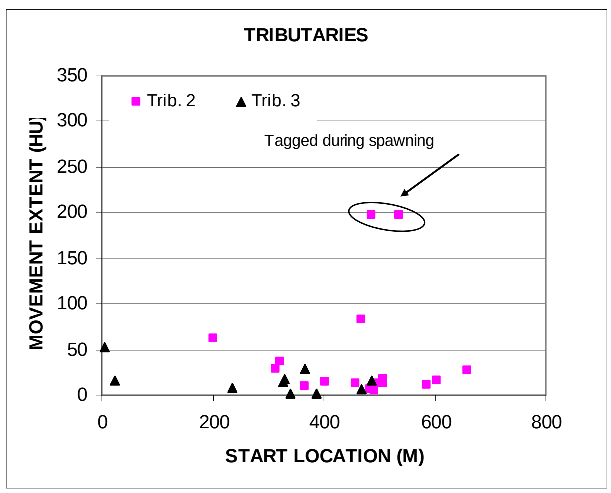


Figure 1. Movement extent (i.e., difference between most upstream and downstream locations in habitat units) for individual fish based on starting location from the mouth of South Fork Hinkle Creek. Lines labeled T2 and T3 show tributary locations.

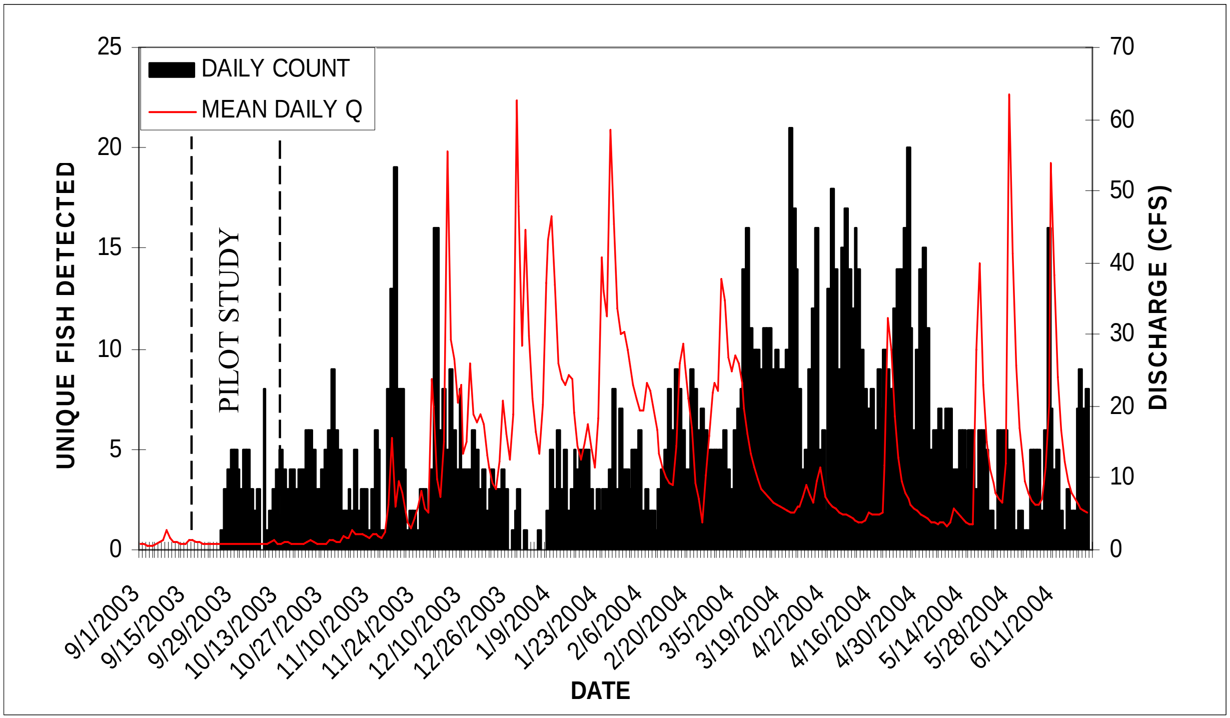


Figure 2. Time series plot of stream discharge superimposed on a frequency distribution of unique fish detections at stationary antenna sites. Detections are based on only the first detection of individual fish for each day. Both mainstem and tributary detections are represented.

Recognizing factors influencing distribution of coastal cutthroat trout in the context of the watershed-scale variables that constrain them may be critical for management of headwater ecosystems. Preliminary evidence suggests differential use of the stream network by fish of different origin. Decreased frequency of stationary behavior events at high and low stage levels may be indicative of reduced use of riffle and pool tail-out habitats (i.e., antenna locations); however, increased duration of stationary behavior events during high stage shows some locations become refuge habitats. The observation of more movements from mainstem habitats to tributaries during high stream stage may be related to refuge or spawning movements. Understanding movement patterns within a watershed can provide insight into the demographic, genetic, and recolonization processes maintaining coastal cutthroat trout populations in headwater streams.

Acknowledgements

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Genetic Variation Maintenance in Rio Grande Cutthroat Trout

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ABSTRACT—Recovery plans for salmonids frequently discuss the need to maintain the genetic diversity of the 'species' in recovery efforts and the development of hatchery stocks. For many types of salmonids, there is also the problem of hybridization between various species and subspecies. For west-slope cutthroat trout (*Oncorhynchus clarki lewisi)* there have been various opinions presented about whether hybridized populations should be considered as part of the sub-species under the Endangered Species Act. Intuitively, the more stringent the requirement for genetic purity the fewer the number of populations that will be included within the sub-species. Exclusion of slightly hybridized populations, however, may also exclude a significant proportion of native genetic diversity. Populations of Rio Grande cutthroat trout (*O. c. virginalis*) have been characterized using microsatellite markers and compared against known rainbow trout populations (*O. mykiss*) to give an index of hybridization. Alleles have been characterized as either cutthroat specific, rainbow specific, shared, or unclassified. Cutthroat trout and shared alleles are well represented in populations with low or no introgression, while the unclassified alleles are more variable and less likely to be represented with fewer populations.

Evaluation of Large Trap Nets for Lake Trout Removal in Lake Pend Oreille, Idaho

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ABSTRACT—We assessed the use of large trap nets to suppress the exotic population of lake trout *Salvelinus namaycush* in Lake Pend Oreille, Idaho. While trap netting we also monitored the mortality rates of non-target species and estimated the abundance of lake trout. The nets varied in lead heights and mesh size as part of the assessment to identify the most effective gear. Using the Schnabel multiple-census population estimator, we estimated that Lake Pend Oreille contained 6,376 lake trout > 52 cm after handling 1,183 lake trout (marked and unmarked) during the six month study. Based on the population estimate, we caught 16% of the population > 52 cm in length. Our catch rates ranged from a high of 3.0 lake trout/net/day (during spawning season) to a low of 0.13 lake trout/net/day (during the winter season). We captured a total of nine species with the trap nets and found the catch and mortality of most non-target species was relatively low. Due to lake bathymetry (steep shorelines and few shallow areas), these nets could not be set in many of the lake trout habitats found within the lake. Data indicated that the large trap nets alone may not be a suitable way to suppress the lake trout population in a short period of time, since they caught only $^1/_6$ ($^1/_5$ to $^1/_8$ based on the confidence interval) of the population. However, they may have utility as part of a long-term program of lake trout control. Trap nets also proved to be a valuable research tool for collecting lake trout for population estimates and sonic tagging projects without causing high mortality to non-target species.

Seasonal Movements and Habitat Use Patterns of Fluvial Trout Populations in the Upper Salmon River Basin, Idaho

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ABSTRACT—Information on the movements, behavior, and critical habitats of fluvial salmonid populations native to the Salmon River basin, Idaho is minimal. The upper Salmon River basin provides a unique study area due to its diversity of lotic habitats. Many tributary streams have been negatively impacted by various land use activities, while others found in wilderness areas have been relatively undisturbed. The goals of this study are to identify migration patterns, critical spawning, and seasonal habitats of fluvial trout populations within the Salmon River drainage. In 2003 and 2004, 67 bull trout (*Salvelinus confluentus*), 39 westslope cutthroat trout (*Oncorhynchus clarki lewisi*) and 43 rainbow trout (*O. mykiss*) were monitored using radio telemetry. Movements were monitored by ground relocations and fixed telemetry stations located at major tributaries. Fish were relocated on a weekly basis, allowing for the observation of migration timing and movement corridors, as well as the identification of spawning areas and seasonal habitats. During the first year of study, previously unknown spawning and over wintering areas have been identified for fluvial trout populations in the upper Salmon River basin. This information will aid in future management decisions by agencies working in the upper Salmon River basin and help guide habitat conservation and improvement projects.

The Effects of Non-Native *Salmo Trutta* (Brown Trout) on Growth and Fitness of *Oncorhynchus Clarki Virginalis* (Rio Grande Cutthroat Trout) in Stream Enclosures on the Rio Cebolla, Jemez Mountains, New Mexico

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ABSTRACT—The purpose of this study was to examine the effects of interspecific competition between juvenile brown trout and Rio Grande cutthroat trout. One 28-day manipulative experiment was conducted on the Rio Cebolla, Jemez Mountains National Recreation Area, New Mexico in August of 2004. Sixteen temporary barriers were placed in the stream, effectively blocking 8 twenty-meter sections, and fish were stocked at a constant biomass within each section. Four of the blocks consisted of a sympatric treatment combination of 10 Rio Grande cutthroat trout and 10 brown trout. The remaining four blocks were used as allopatric controls. Two of the control treatments consisted of 20 Rio Grande cutthroat trout, and the other two consisted of 20 brown trout. In order to record growth rate and change in body condition, fish were recaptured at weekly intervals from their respective treatments using electrofishing techniques. Our analyses found that Rio Grande cutthroat trout growth significantly declined ($p < .001$) in sympatric treatments when compared to allopatric controls. In contrast, we found that brown trout growth significantly increased ($p < .005$) in combined-species treatments when compared to controls. These results suggest that brown trout displace Rio Grande cutthroat trout from optimal foraging habitats, and the subsequent decrease in Rio Grande cutthroat trout body condition suggests the former is accomplished through direct aggressive interactions.

Introduction

Worldwide, biological invasions are second only to that of habitat loss and destruction as a cause of the loss of biodiversity (Williamson 1996). The invasion of nonnative species into new ecosystems is accelerating as the human population continues to grow. Species of plants, animals, and microbes have been introduced for reasons ranging from agriculture to recreation. Only a small percentage of nonnative introductions result in conspicuous environmental impacts (Lodge 1993, Williamson 1996), however each introduction holds consequences for populations, communities, or ecosystems. Throughout North America, freshwater systems have proven particularly vulnerable to invasion from nonnative species. In the United States alone, over 100 aquatic invertebrate species and 138 nonindigenous fish species have been introduced (Courtenay et al. 1991, Courtenay 1993). Isolated freshwater desert systems, such as those found in New Mexico, experience relatively rapid effects from nonnative fish introductions. Consequently, there is a need for research to identify deleterious effects of these nonnative introductions, and mechanisms by which nonnatives may be affecting populations and communities.

Because Rio Grande cutthroat trout (*O. c. virginalis*) has been reduced to 5-7% of its historic native range, there is a need to determine the underlying mechanisms of this reduction. Contemporary data suggest declines in most of these species, particularly Rio Grande cutthroat trout, and possible relationships among these declines with introductions of nonnatives such as *O. mykiss* (rainbow trout), *Salvelinus fontinalis* (brook char), brown trout (*S. trutta*), and *Catastomus commersoni* (white sucker) (NMDGF 2002). The mechanisms by which these nonnatives species may be affecting native populations include hybridization, resource competition and predation.

Researchers in both academia (Trotter 1987, Wang and White 1994), and government agencies (Stefferud 1988, NMDGF 2002) have suggested that brown trout outcompete cutthroat trout through higher recruitment rates and increased food–resource acquisition as a result of heightened aggressive behavior (Nillson and Northcote 1981). Wang and White (1994) conducted laboratory competition experiments between brown trout and *Onchorhynchus clarki stomias* (greenback cutthroat trout), and discovered greenback cutthroat trout were displaced into upstream riffles (areas of scarcest food), when in sympatry. Additionally, the researchers found that brown trout solely occupied pool habitats (areas nearest food and most energy efficient) when the two species were in sympatry. In northern and central New Mexico streams where brown trout were introduced or invaded, Rio Grande cutthroat trout appear to be more abundant in headwater streams and brown trout are more abundant downstream. A similar pattern is seen in the northeastern United States between native brook char and brown trout. In many of the northeastern streams brown trout will force populations of brook char to retreat further upstream each year (Nyman 1970). Fausch and White (1981) presented data suggesting that brook char and brown trout compete for preferred resting positions, a critical and scarce resource, and that brown trout were dominant competitors suggested by the ecological release observed in brook char when brown trout were removed. Because brown trout and Rio Grande cutthroat trout evolved separately in similar environments they might be expected to exhibit a high degree of niche overlap, and possible competition for resources. If invading species interact with natives primarily through competition for limited resources, removal of the exotic should produce a compensatory increase in native populations (D'Antonio et al. 2001).

In general, superior competitors gain better foraging opportunity and increased protection from predators with concomitant increases in fitness, especially in species with variable growth patterns such as fish (Metcalfe et al., 1995). Growth in fishes is a sensitive index of resource availability and acquisition, and is generally positively related to fitness (Hall et al. 1970; Werner and Hall 1976). Bromage et al. (1992) reported positive correlations between body size, egg size and number of eggs produced in hatchery-raised salmonids. Jones and Bromage (1987) documented a 25% decrease in salmonid egg production associated with a 25% decrease in daily food ration. Therefore, competition for food resources can be expected to have direct effects on growth and body size and indirect reproductive consequences that decrease overall fitness.

The purpose of this study was to examine interspecific competition between Rio Grande cutthroat trout and nonnative brown trout. The experiment described here evaluates the consequences of competition on growth and body condition. Niche shifts in sympatry indicated by effect on growth is considered evidence of competition (Werner and Hall 1976; Diamond 1978; Gatz et al. 1987), but overlap in resource use alone does not indicate that species are competing (Sale 1979). In this study, growth in body mass and length was used as an indication of competition and effects on body condition was used as an indirect measure of its effects on fitness.

Materials and Methods

This study was conducted within the Rio Grande basin on the Rio Cebolla in the Jemez Mountains National Recreation Area, New Mexico (N 35.97011º W 106.66127º) (Figure 1). The Rio Cebolla is a first-order, cold-water trout stream with a substrate dominated by sand and gravel. It drains an approximate area of 35 km^2. The Rio Cebolla is a tributary of the Rio Guadalupe, which joins the Jemez River, a direct tributary to the Rio Grande. Its relatively small size made it an excellent site to conduct experiments within constructed enclosures.

Historically, the Rio Cebolla was within the native range of Rio Grande cutthroat trout. At the time of this study, the upper reach contained a restored population protected by a migration barrier (McKinney Pond). The barrier provides the restored population with protection from invasion of nonnative brown trout and rainbow trout. Because this study used nonnative brown trout, it was conducted downstream from McKinney Pond to ensure protection of the restored population of Rio Grande cutthroat trout. The fish community in this reach of the Rio Cebolla included brown trout, rainbow trout, Rio Grande sucker, and Rio Grande cutthroat trout.

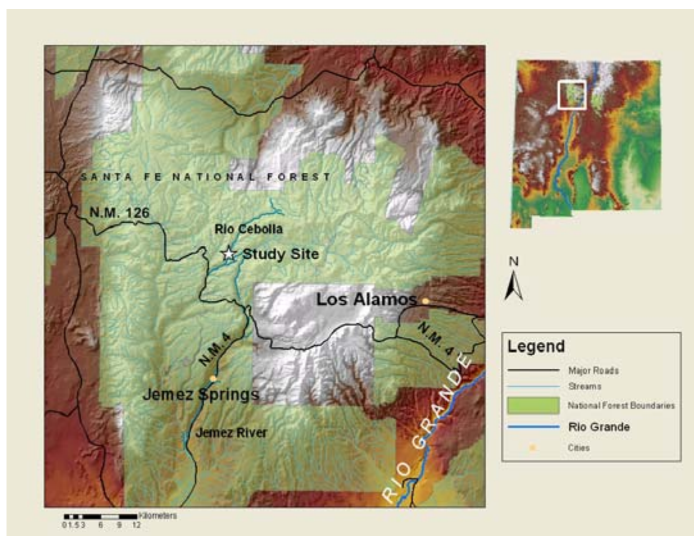


Figure 1. The study site on the Rio Cebolla is located in north-central New Mexico. It is a tributary to the Jemez River and part of the Rio Grande drainage basin.

A total of eight 20 m sections of the Rio Cebolla were selected as experimental sites. Each end of the experimental enclosures was delimited by a panel of 6.35 mm (1/4 in) expanded metal screen, reinforced with angle iron and reinforcing bar. Each screen spanned the entire width of the stream and provided complete enclosure from the stream substrate to 75 cm above the surface of the water. After the eight treatment enclosures were adequately blocked, all fish within them were removed using a Smith-Root LR-24 backpack electroshocker.

Total fish biomass was estimated and fish were placed downstream of all experimental enclosures. Mean biomass per unit area was subsequently used as a target for stocking each experimental enclosure. All enclosures were surveyed by electrofishing twice in the following two days in order to test the effectiveness of the temporary barriers and total removal of fish.

Data Collection and Analyses

The experimental design for the experiment consisted of a one-way classification analysis of variance with 3 treatments in a completely randomized design with two replicates of each treatment. The three replicated treatments consisted of allopatric Rio Grande cutthroat trout, allopatric brown trout, and two sympatric Rio Grande cutthroat trout and brown trout treatments (Table 1). Each treatment (allopatric or sympatric) began with a total of 20 like-sized fish, which yielded a total biomass consistent with that supported by the stream prior to the experiment This type of experimental design for testing interspecific competition was described by Underwood (1986). The abundance of wild brown trout in the Rio Cebolla allowed for the selection of equal sizes. Individual fish within each enclosure had a mass equal to 35 g ± 5 g, yielding a total biomass of 700 ± 50 g per 20 m enclosure. Each enclosure was randomly assigned a treatment. The fixed effects model (completely randomized hierarchical) was:

$$Y_{ijk} = \mu + T_i + R_{j(i)} + e_{ijk}$$

where μ is the overall mean, Y_{ijk} is the k^{th} observation (length or mass) in the j^{th} replicate ($R_{j(i)}$) of the i^{th} treatment (T_i = allopatric Rio Grande cutthroat trout, sympatric Rio Grande cutthroat trout – brown trout, or allopatric brown trout), and e_{ijk} is the residual error. Analyses were conducted using the general linear models procedure of SAS (SAS Institute, Inc. 1989). Significance in the ANOVA was judged by the Type III (partial) sums of squares because sample sizes were unbalanced. Least squares means for treatments were obtained from the ANOVA (Goodnight and Harvey 1978) and used for pairwise comparisons of treatments.

Table 1. Experimental treatments of Rio Grande cutthroat trout (RGCT) and brown trout (BT) selected to examine interactions.

Species	BT	RGCT
BT	BT * BT (allopatric)	BT * RGCT (sympatric)
RGCT	RGCT * BT (sympatric)	RGCT * RGCT (allopatric)

All Rio Grande cutthroat trout used in the experiment were obtained from the Seven Springs Fish Hatchery. Fish used in the experiment were hatchery produced progeny of fish that originated from the wild population in the Rio Las Vacas in 2002. All brown trout used for the experiment were collected from the Rio Cebolla using electrofishing techniques. Fish within individual treatments were uniquely marked using colored elastomer (Northwest Marine Technology, Inc.) injected subcutaneously utilizing combinations of four anatomical locations and two colors.

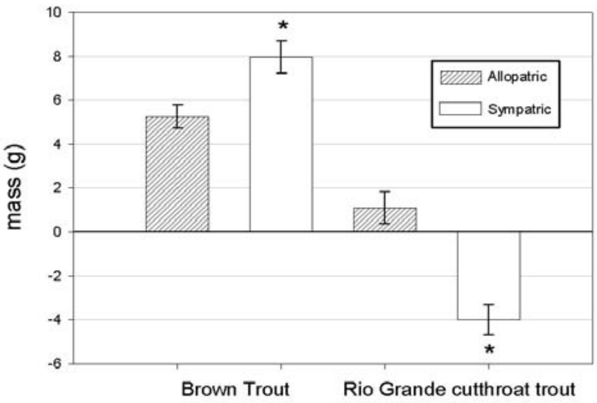
The experiment took place over a 28-day period between 08/13/03 and 09/09/03. This experiment was initially designed to span a 30-day period but heavy rainfall forced termination of the experiment two days early. Fish were recaptured from every enclosure at day 7, 18, and 28 using a backpack electroshocker (Smith-Root Inc.). Length and mass were recorded for each fish. All individuals were then released back into their respective enclosures. Temperature was recorded at five minute intervals using two water temperature loggers (HOBO), which were placed at the upper and lower enclosures. At the completion of this experiment all fish were euthanized and returned to the laboratory for examination of gut contents, assessment of fat deposition (Goede 1993) and measurement of fin condition. Fat deposition was qualitatively assessed through examination of the amount fat surrounding the pyloric caecum. Each individual was assigned a body condition ranking of 0, 1, 2, 3, or 4, which represented no fat, < 50% fat, approximately 50% fat, >50% fat, and 100% fat, respectively. In order to determine any significant differences between treatments, a Chi-square test of homogeneity was conducted on the body condition rankings. Fin condition was assessed by incidence of caudal fin damage or removal, which was either partial or complete. The proportions of fin damaged individuals were used to make comparisons within species and between treatments using t-tests.

Results

We surveyed four of eight enclosures to obtain an accurate estimate of the naturally occurring fish biomass throughout the study site. The four enclosures used were 1, 3, 4, and 8 all of which were randomly selected. Mean total biomass across all four enclosures was 716.64 g (SE = 62.75), which was used throughout the experiment for individual treatment biomass.

Due to flood flows that occurred on the final day of the experiment a total of 18 of 40 allopatric Rio Grande cutthroat trout and 19 of 40 sympatric Rio Grande cutthroat trout were recovered on the final recapture day of the 28-day manipulative experiment, whereas a total of 27 of 40 allopatric brown trout and 22 of 40 sympatric brown trout were recovered. No unmarked individuals were recaptured throughout the experiment. By including temperature as a fixed affect in the ANOVA model it was determined that temperature had no significant effect on growth of fish ($P > .4$). Overall significance of treatments was assessed with Type III sums of squares. The model was significant (ANOVA, $F_{(3, 82)} = 60.10$; $P < .0001$) with the dependent variable being difference in mass at the end of the experiment and start of the experiment, hereafter referred to as growth in body mass (g), and body length (mm). A Shapiro-Wilk test for normality was conducted on growth in body mass and total length, and was found to be normally distributed ($P = .8291$). Because ending sample sizes were unequal, least squares means were used to make individual comparisons between the three treatments.

Fish growth in body mass in all three treatments were found to be significantly different from zero ($P < .05$), and significantly different from each other using a Bonferonni adjustment to account for type II errors. Sympatric brown trout gained significantly more body mass than allopatric brown trout ($P = .0027$), however sympatric Rio Grande cutthroat trout displayed negative growth, which was significantly less than allopatric Rio Grande cutthroat trout growth ($P < .0001$), which was positive (Figure 2).



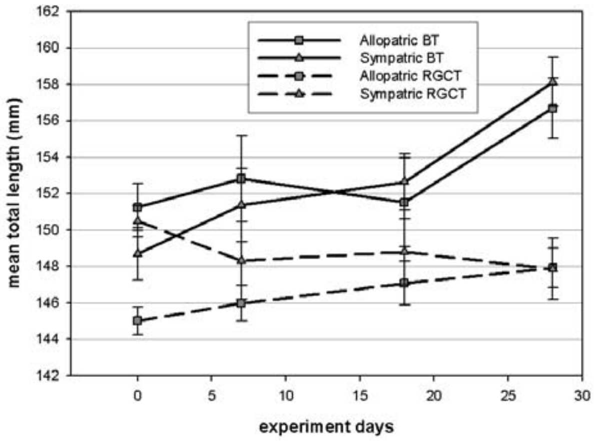


Figure 2. Mean 28-day change in mass (g) of Brown trout and Rio Grande cutthroat trout in allopatric and sympatric treatments in experimental enclosures throughout the experiment. An asterisk indicates a significant difference at p < 0.0083.

Figure 3. Mean 28-day change in body length (mm) of Brown trout and Rio Grande cutthroat trout in allopatric and sympatric treatments in experimental enclosures throughout the experiment.

Additionally, we found a significant effect of treatment on growth in body length (ANOVA, $F_{(3, 82)} = 14.47$; $P < .0001$). Allopatric and sympatric brown trout did not grow significantly different from each other ($P = .5$), but both grew significantly more than allopatric and sympatric Rio Grande cutthroat trout ($P < .001$, and $P < .0001$), respectively. Interestingly, there was a negative mean growth in body length of -.91 mm in sympatric Rio Grande cutthroat trout, which was significantly less than allopatric Rio Grande cutthroat trout, which displayed positive growth in body length (pP = .003) (Figure 3).

Post-mortem fat content and fin lossin brown and allopatric Rio Grande cutthroat trout ($X^2 = 5.48$, $P = .139$) and no difference was found between allopatric and sympatric brown trout ($X^2 = 4.65$, $P = .199$). A significant difference was found between sympatric brown trout and sympatric Rio Grande cutthroat trout ($X^2 = 28.11$, $P < .001$). The incidence of Rio Grande cutthroat trout caudal fin damage was significantly higher in sympatry (88.8%) with brown trout as compared to allopatric treatments (11.1%) ($t_{(.01, 37)} < 3.042$).

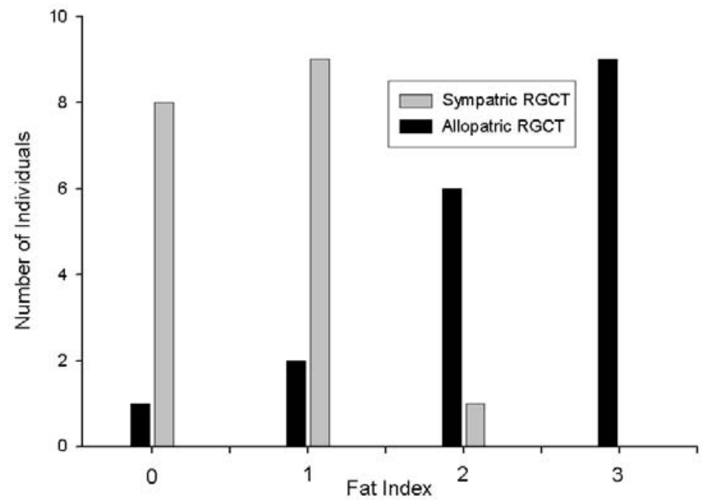


Figure 4. Post mortem fat analysis, using a standardized health condition profile, of Rio Grande cutthroat trout in allopatric and sympatric (w / S, trutta) treatments from Experiment 1 where a value of 0 represents 0% fat present on the pyloric caecum, 1 represents < 50%, 2 represents 50%, and 3 represents > 50%.

Discussion

This experiment supports our prediction that in unnatural sympatry nonnative brown will have significant effects on the growth of Rio Grande cutthroat trout. Using equal-sized fish in a natural setting, brown trout were clearly dominant competitors over Rio Grande cutthroat trout. In nature fall-spawning brown trout would have a size advantage over the spring-spawning Rio Grande cutthroat trout, but our experiments controlled for fish size. We found symmetrical competition between juvenile brown trout and Rio Grande cutthroat trout. Rio Grande cutthroat trout growth was lowest in the presence of brown trout, whereas brown trout growth was highest in the presence of Rio Grande cutthroat trout (Figure 5). In addition to demonstrating negative growth in sympatry with brown trout, Rio Grande cutthroat trout displayed significantly less fat deposition (Figure 9), suggesting displacement into less profitable stream habitat. One possible explanation is that Rio Grande cutthroat trout were displaced into high velocity riffles where the ratio of net-energy-gain / net-energy-loss was very low resulting in the observed fat loss.

Fausch and White (1981) conducted a study to examine resting positions of brook char and brown trout in allopatric versus sympatric conditions. The researchers found that brook char were displaced into less favorable resting positions when in sympatry with brown trout, and demonstrated a niche shift to more favorable, energy efficient positions when brown trout were removed. Fausch and White (1981) postulated that in small headwater streams with gravel and sand dominated substrates, such as that found on the Rio Cebolla, resting positions can be a scarce and aggressively defended resource. Competition for resting position in concert with competition for feeding position, are two possible factors responsible for the observed negative growth of Rio Grande cutthroat trout in sympatry with brown trout.

Wang and White (1994) set out to examine microhabitat shifts, particularly feeding position, in greenback cutthroat trout and brown trout when in sympatry as compared to allopatry. Most notably, they discovered that in sympatry greenback cutthroat trout held feeding positions twice the distance from the food source than when in allopatry. In contrast brown trout were found to hold positions closer to the food source when in sympatry. While the above studies provide valuable information regarding habitat shifts in sympatric conditions, to infer competition from their results may prove erroneous. If the authors were to demonstrate effects on growth, survival, or fecundity as a result of these niche shifts competition may be invoked. Our study directly addressed effects of sympatry on growth and body condition, allowing greater confidence in the declaration of the presence of competitive interaction.

Additionally, the present study discovered strong evidence of aggressive interaction between brown trout and Rio Grande cutthroat trout. In sympatry, 52% of Rio Grande cutthroat trout recovered at the end of the experiment exhibited varying levels of caudal fin loss, wherein allopatry only 11% of Rio Grande cutthroat trout exhibited caudal fin loss. These data confirm levels of active interaction between the two species, and suggest yet another explanation for the documented weight loss of Rio Grande cutthroat trout in sympatry. Aggression and territoriality in brown trout has been well documented (Hardwood et al. 2002; Johnsson et al 2000; Johnsson et al 1999; Wang and White 1994; Griffith 1988). Aggressive bouts and extensive chasing can be metabolically expensive resulting in the loss of fat stores, unless the interaction allows the dominant competitor to exploit additional resources. In our study, the significant loss of fat in sympatry ($p < .0001$) coupled with significantly higher incidence of caudal fin loss ($p < .01$), lend support to the aggressive nature of brown trout Rio Grande cutthroat trout interactions, and a causal mechanism for the observed loss in body mass of Rio Grande cutthroat trout in sympatry with brown trout. Based on our results, we recommend complete removal of nonnative brown trout prior to Rio Grande cutthroat trout repatriation attempts.

Acknowledgements

We thank NMDGF, USFWS, USFS, New Mexico Agricultural Experiment Station, Dr. Rossana Sallenave, Dr. Colleen Caldwell and all field assistants (Emily Boles, Benjamin Duval, Jeremy Padilla, and Thomas Parchman).

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Exotic Trout Effects on Pennsylvania Headwater Stream Food Webs

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ABSTRACT—We held native *Salvelinus fontinalis* (brook trout) and naturalized *Salmo trutta* (brown trout) in enclosures (1.14 m^2) during spring and summer 2003 in central Pennsylvania streams (Tomtit Run, Lingle Run) to measure their effects on benthic communities and detritus processing. Treatments (brook trout, brown trout, and no trout) were replicated at four sites in each stream; all enclosures had an upstream, fishless control section. After a two-week benthos colonization period, one trout (representative of the resident populations' average length) was placed in each enclosure (except for controls). Trout were held in enclosures for three consecutive weeks; subsequently, benthos samples (artificial substrates, leaf packets, and cobble) were collected from all enclosures. Brown trout were larger (18.0 ± 1.8 cm) than brook trout (13.5 ± 2.0) but biomass of the populations were similar within streams. Trout fed actively during trials as evidenced by observation and presence of stomach contents in most individuals at trial termination. Although total biomass of benthic organisms was slightly lower in the presence of trout, there were no significant ($p < 0.05$) differences among treatments on leaf loss, invertebrate abundance, richness, or biomass. Experiments are being performed again in Tomtit Run and Lingle Run from May to October 2004.

Wild Trout VIII—Presenter Biographies

Note: This may not be an all-inclusive list. We apologize if information contained in this table is in anyway inaccurate. Information on presenter biographies, gathered during the conference, was not confirmed with each author. However, we did our best to present to you a "brief" synopsis on the biography of each presenter.

Presenter	Presentation	Biography
Bosse, Scott	In Defense of Natives: Why Protecting and Restoring Native Trout should be our Highest Priority	Rivers Conservation Coordinator for the Greater Yellowstone Coalition. B.S. from University of Vermont and M.S. from University of Montana. Past Decade—Native fish restoration in Idaho, Montana, Washington and Oregon. Currently focused on: Establishing a native fish sanctuary for Yellowstone and the Snake River fine spotted cutthroat in Wyoming's Snake River Drainage using Wild and Scenic Rivers act.
Buhyoff, Matt	Managing a Trout Tailwater in the Presence of a Warmwater Endangered Species	2nd year Master's student at Virginia Tech University, major advisor is Don Orth. B.S. in Environmental Science at University of Michigan. Master's Program–Production and Management of non-game fish in a tail-water situation on the Smith River in SW Virginia.
Burrows, Andy	Wild Brown Trout in an English Chalk Stream: Modeling Habitat Juxtaposition as Aid to Watershed Rehabilitation	Middlesex University. About to submit a PhD looking at Brown Trout habitat relationships in an English chalk-stream. B.S. in Geography. M.S. in Environmental Management from University of London – dissertation – River Test? Founding member of the Wild Trout Trust in UK. Life long fly-fisherman with 20 years fishing chalk-streams.
Carline, Bob	Responses of Streams to Riparian Restoration in the Spring Creek Watershed, Central Pennsylvania	Bob Carline began his professional career in 1967 when he joined the Wisconsin DNR's Coldwater Research Group, which was directed by Robert Hunt. In 1976, Bob moved to the Ohio Cooperative Fishery Research Unit and in 1984, he took over as Leader of the Pennsylvania Cooperative Fish and Wildlife Research Unit His major research efforts have focused on ecology and management of trout streams. He has been a member of Trout Unlimited for more than 30 years and he is a past president of the American Fisheries Society. (If anyone cares: degrees from Rutgers, Oregon State, U. of Wisconsin, Madison).
Cornett, Scott	Wiscoy Creek, New York; A 60-year Transition from Put-and-take Stocking to Wild Trout Management	Scott is a graduate of Syracuse University – B.S. in Fish & Wildlife Biology. Employed as a fishing Biologist with N.Y. Dept. of Environmental Conservation, since 1990. Responsible for trout management in the western six counties of the state.

Presenter	Presentation	Biography
Colyer, Warren	A Watershed Scale Approach for Conserving Fluvial Bonneville Cutthroat Trout in the Bear River	Warren obtained a BA in Political Science from the University of Washington; returned to school after several years of play to pursue a BS in Fisheries Colorado State University. Completed graduate work at Utah State University in 2002; MS in Aquatic Ecology. Graduate work involved the study of migration and movement patterns of Bonneville cutthroat trout in the Bear River. Now serve as the field coordinator for TU's Strategies for Restoring Native Trout Program. This work finds me spending much of my time working on Lahontan cutthroat trout in northeastern Nevada. However, we have recently begun a restoration effort for Bonneville cutthroat trout in the Bear River, which is what I will be talking about.
Erickson, Jack	Recovery and Management of Native and Non-native Fish Populations in the Bear Butte Creek Watershed in the Black Hills of South Dakota Following Historic and Recent Mining Activity	Received his M.S. in Biology from the University of Minnesota-Duluth and M.S. in Civil Engineering from the South Dakota of Mines and Technology. Currently a candidate for a Ph.D. in Water Resources Engineering at the South Dakota School of Mines and Technology. Currently employed by the South Dakota Dept. of Game, Fish and Parks. Jack is the coldwater fisheries biologist for South Dakota responsible for managing the stream and reservoirs in the Black Hills of South Dakota. Jack's duties include preparing management plans, developing trout stocking guidelines for the Black Hills, recommending fishing regulations, and evaluating the effectiveness of the stockings and fishing regulations.
Faast, Tony	Regaining Public Trust	Biologist, US Fish and Wildlife Service. B.S. in Wildlife Management from Oregon State University and his M.S. in Outdoor Education from Southern Oregon State University. 30 years of State and Federal experience as a Fish Squeezer, Hunter Educator, Habitat Protector, and Public Involvement Victim/Coordinator. Proud moments of Career: President – Oregon Chapter AFS, Survivor- over 100 public meetings. Staff member: Interagency Communications Workshop providing communication training for today's resource managers.
Fowler, Neville	Partnerships in Trout and Native Fish Management—An Australian Case Study	A FW Regional Fisheries Manager in the State of Victoria, Australia. Has been a fisheries officer in Australia since the late 1960's and has worked in the states of New So. Whales, Tasmania and Victoria. He started out as a Marine vessel operator, moved into fisheries law enforcement and now serves as fishery management.
Fredericks, Jim	The Status and Management of Yellowstone Cutthroat Trout in the South Fork of the Snake River, Idaho	B.S. in Psychology from University of Idaho. Changed course and received M.S. in Fisheries from University of Idaho in 1994. Worked as a Research and Management Biologist for Idaho Fish and Game in Idaho Panhandle. Past 3 years has been Regional Fishery Manager in Upper Snake Region.
Harding, Roger	The Development and Evaluation of Conservative Trout Regulations in Southeast Alaska Based on Length at Maturity	Roger has worked in Alaska since 1980 and has been with the Alaska Dept. of Fish & Game, Sport Division for over 20 years. Since 1988, he has been conducting trout research on cutthroat trout and steelhead, in Southeast Alaska. Roger received his B.S. from Humboldt and his M.S. from the University of Alaska, Fairbanks. He currently lives and works in Juneau, Alaska.

Presenter	Presentation	Biography
Harig, Amy	A Watershed Scale Approach for Conserving Fluvial Bonneville Cutthroat Trout in the Bear River	Program Coordinator for TU Native Trout Programs. PhD from Colorado State University and M.S. from Cornell University. Live and work out of Boise, Idaho.
Hewitt, Laura	Lessons Learned from Trout Unlimited's Watershed Programs	Laura Hewitt is the Watershed Programs Director for Trout Unlimited. She oversees the on-the-ground watershed restoration projects across the nation and staff who manage them. Previously she was the Upper Midwest Conservation Director, and she originally came to the organization to be the project manager for TV's Home Rivers Initiative in the Kickapoo Watershed in southwest Wisconsin. She has a B.S. in Biology from the University of North Carolina, and received a master's degree from the UW -Madison in Conservation Biology and Sustainable Development. She also served in the Peace Corps in Liberia, West Africa and the Dominican Republic.
Horner, Ned	Managing the Threat Posed by Lake Trout to the Lake Pend Oreille, Idaho, Fishery	Regional Fisheries Manager Panhandle Region IDFG since 1985. Has been with IDFG since 1980. B.S. in Fisheries from Colorado State University. M.S. from University of Idaho in Fisheries.
Hubert, W.A.	Ecological, Social, and Economic Issues Related to Bioinvasive Species and the Preservation of Cutthroat Trout in the Western United States	Employee of the USGS, Fish and Wildlife Coop Unit at the University of Wyoming and a Professor in the Department of Zoology and Physiology where he has taught students and conducted research on just about all aspects of fishery issues in the State of Wyoming for the last 22 years. Dr. Hubert is a native of Illinois. Received his PhD from Virginia Tech.
Hudy, Mark	A Large-Scale Risk Assessment of the Biotic Integrity of Native Brook Trout Watersheds	B.S. Fisheries Virginia Tech, M.S. Fisheries Utah State, National Aquatic Ecologist-East; USDA Forest Service; Life member American Fisheries Society.
Hulett, Patrick	Research and Management of Rainbow/Steelhead Populations in the Kalama River, Washington: A Smorgasbord of Life History Forms, Regulations, and Fishing Opportunities	B.S. and M.S. from Oregon State University. Currently lives and works out of Kelso, Washington. Pat has made a career working on this project for the Washington Dept. of Fish and Game for the past 18 years.
Jacklyn, Bob	Session 3—Panel Discussion	Fly shop owner and guide out of West Yellowstone. Bob has been involved with fly fishing industry for over 30 years and is well known by fly fisheries throughout the Country. He has served on the Fed of Fly Fisherman's Casting Board of Directors. He has been a long time leader in the Federation Program.

Presenter	Presentation	Biography
Koel, Todd	Effects of Increased Angler Use on a Native Cutthroat Trout Population in Slough Creek, Yellowstone National Park	Fish Supervisor at Yellowstone National Park. M.S. and PHD from North Dakota State University.
Kulp, Matt	A Case History in Fishing Regulations in Great Smoky Mountains National Park: 1934-2004	Matt received his B.S. from Penn State University in 1992 and his M.S. from Tennessee Tech. University in 1994. 1992—Today: Great Smoky Mountain National Park working for Steve Moore. Areas of long-term fish community monitoring native fish restoration. Interest: Salmonid population dynamics, acid deposition, brook trout genetics, utilizing volunteers in fisheries projects. Wife and I live in Wears Valley, Tennessee.
Lyman, John	Writings on Angling and Ethics	John is an Aquatic Education Coordinator, Alaska Dept. of Fish and Game (22 years). V.P., Sonny Mederos Foundation. Board member/trainer for the 4-H sport fishing paper. Coordinator and national trainer for HOFNOD. Board member of the Aquatic Resources Education Association. Education co-chair for AREA. Serves on the Alliance for Fly Fishing Education. Serves on the Recreational Boating and Fishing Foundation Stewardship working group. V.P. for Education Federation of Fly Fishers. Collects and reads old fishing books, tracts, magazines, etc. Builds bamboo fly rods. Writing a book on Catch and Release. Also on the organizing committee for Wild Trout VIII.
McGurrin, Joseph	Native Trout Recovery in Arizona: Past, Present, and Future	Resource Director for Trout Unlimited National Office. B.S. in Biology from William and Mary and his M.S. in Fishery Science from the University of MD. Currently works on fishery restoration efforts for a variety of inland native trout species.
McKinley, Dan	The Role of Government in Building Civic Capacity at the Watershed Scale; a Case Study of the White River in Vermont	Dan McKinley is a Fisheries Biologist with 15 years experience with the U.S. Forest Service with an emphasis on river habitat assessment, monitoring, and restoration. Dan's work on five National Forests has taken him to Colorado, Montana, New Hampshire, and Vermont. For the past two years, he has provided technical assistance to the White River Partnership on river restoration projects and monitoring. Dan received his B.S. in Biology from Stockton State College in New Jersey and his M.S. in Zoology from the University of Maine. Dan and his family make their home in eastern Vermont, along the banks of the White River.
Mitro, M.	Stocking Trout of Wild Parentage to Restore Wild Populations: An Evaluation of Wisconsin's Wild Trout Stocking Program	Wisconsin DNR for 1.5 years. Post doc EPA from Rhode Island, PhD from MSU Henry's Fork, M.S. from University of Vermont in Walleye, and B.S. from Colget University. Coldwater Fish Research—Stateside Trout Biologist.

Presenter	Presentation	Biography
Mohn, Larry	Long-term Results of Mitigating Stream Acidification Using Limestone Sand in St. Marys River, Virignia	Department of Game and Inland Fisheries for 29 years. Regional Fish Manager and Coldwater Coordinator. B.S. from Penn State and M.S. in Fisheries from Virginia Tech.
Morgan, Ray	Managing Brook Trout Populations in an Urbanizing Environment	Dr. Ray Morgan is a Full Professor with the Appalachian Laboratory of the University of Maryland Center for Environmental Science located at Frostburg, MD. He received his B. S. degree from Frostburg State University in 1966 with a major in biology and minors in chemistry and secondary education. In 1971, he earned his Ph.D. from the Department of Zoology, University of Maryland at College Park with an animal ecology major and physiology minor. During his career at Chesapeake Biological Laboratory, Battelle Columbus Laboratories, and Appalachian Laboratory, his research has focused on pollution ecology and fisheries genetics, with special emphasis currently on acidic deposition and acid mine drainage, and genetics of Appalachian fishes. Dr. Morgan and his graduate students are currently examining effects of urbanization on Maryland streams.
Partridge, Fred		Idaho Dept. of Fish and Game in Boise. Resident Fishery Coordinator – Rules & Permits. Past Regional Fishery Manager in the Magic Valley Region of South Central Idaho. Have worked with variety of species from golden trout and desert pupfish in California to white sturgeon and burbot in North Idaho.
Reeser, Steve	An Analysis of Wild Trout Anglers in Virginia	Steve received his B.S. from Lock Haven University in Pennsylvania and his M.S. from Tennessee Technological University. He worked for the Kentucky Dept. of Fish and Wildlife Resources for several years and has worked for the Virginia Dept. of Game and Inland Fisheries for the past 6 years. Currently is a District Fisheries Biologist in the Shenandoah Valley Region of Virginia.
Schenk-Baker, Gretchen	Balancing Bonneville Cutthroat Trout with Non-Native Salmonids in Great Basin National Park	Has been working as a fisher biologist at Great Basin National Park for the last five years and has been involved in all phases of native cutthroat trout restoration work in the Great Basin National Park. Has coordinated activities with Nevada Dept. of Fish and Game, TU, Forest Service, and the local community.
Schill, Dan	Population Trends and an Assessment of Extinction Risk for Westslope Cutthroat Trout in Select Idaho Waters	Fish Research Supervisor IDFG.
Seibel, Dave	McGee Lake, Wisconsin: 35 Years of Trout Management—Past Successes and Future Challenges	B.S. from University of Wisconsin, Stevens Point and M.S. from University of Massachusetts. Fisheries Biologist with Missouri Dept. Conservation for over 6 years. Fisheries Biologist with Wisconsin DNR for 6 years. Worked in Northeast part of Wisconsin on a variety of Coldwater & Warmwater systems.

Presenter	Presentation	Biography
Shepard, Brad		Cutthroat Trout Conservation Coordinator for State of Montana—MFWP. 25 Years FWP. B.S. from Montana State University and M.S. from University of Idaho. Currently PhD students Al Zayle and Mark Taper. Works out of Bozeman, Montana.
Spayd, Pamela	Population Trends and an Assessment of Extinction Risk for Westslope Cutthroat Trout in Select Idaho Waters	Pamela R. Spayd is a Watershed Specialist for Berks County Conservation District. Pamela R. Spayd is a native Pennsylvanian, born, raised and currently working in Reading, Pennsylvania; about 90 minutes northwest of Philadelphia. A nature enthusiast, Pam enjoys hiking on the Appalachian Trail, canoeing and studying streams. After graduating from Shippensburg University with a B.S. in GeoEnvironmental Studies, Pam became employed by the Berks County Conservation District. Over the past three years, she has written and received over $250,000 of grant money from different sources to implement water quality improving best management practices on agricultural land. Through her work, she has educated numerous community-based organizations to conduct volunteer biological, physical and chemical water quality monitoring.
Stelfox, J.	Quirk Creek Brook Trout Suppression Project	Fish Biologist FFW 25 years. Alberta F & W. Fish Manager for fisheries SW of Calgary.
Winter, Brian	Trout Unlimited and the Pennsylvania Mennonite Community - A Watershed Partnership	Brian received a B.S. in Natural Resources Planning and Interpretation from Humboldt State University in 1978, a M.S. in Fisheries from Humboldt State University in 1983, and a Ph.D. in Fisheries from the University of Washington in 1992. I worked for the Point No Point Treaty Council as a fisheries management biologist from 1985-1988 and for the National Marine Fisheries Service from 1988-1993 overseeing hydropower licensing for most of western Washington. I have been the Elwha Project Manager for the National Park Service since 1993.

Exhibitors

Advanced Telemetry Systems, Inc
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Phone: 763-444-9267 • Fax: 763-444-9384
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Richard Reichle, Co-Owner of ATS and his wife Elly manned the ATS booth at the International Wild Trout Symposium, September 20-22, 2004. R. Peter Van Gytenbeek and Marty Seldon had dinner with the couple and told them of our need of a grant to strike the A. Starker Leopold Medal. Within a few days after the symposium, Mr., Reichle advised that ATS had graciously approved our grant for $3,800.

Larry Kuechle President, Engineer, Owner
Richard A. Huempfner, M.S. Vertebrate Ecology, Scientific Sales & Project Consultant, Owner
Richard A. Reichle, M.S. Wildlife Management, Senior Engineer & Customer Liaison, Owner

Advanced Telemetry Systems, Inc. was founded in 1981 by a group of biologists and electronics engineers who have a combined 100+ years of experience in the biotelemetry field. A privately-held corporation, ATS is located in Isanti, Minnesota. Their facility has grown to keep pace with an expanding global demand for their innovative and cost-effective biotelemetry solutions. The most recent expansion, completed in 1997, more than doubled the facility size. ATS includes space for R&D, manufacturing, warehousing, distribution and operations all under one roof. They are also proud of the fully-equipped fitness center designed and used by our now nearly 50 employees.

ATS' owners are "hands-on" biologists and engineers who work an experienced and dedicated staff in every aspect of our business. ATS' broad line of transmitters is available for virtually any species. Our technologically advanced receivers and data collection computer can maximize the quality and efficiency of your wildlife data collection efforts

For those of you that electronically track fish and wildlife, please consider ATS products.

#

Kinship Conservation Institute

The Kinship Conservation Institute offers one-month paid fellowships ($4,500 each) in Bozeman, Montana, for conservationists who are interested in learning how markets can work to improve the environment. KCI is a unique opportunity for practitioners to spend a month focusing on a work-related environmental problem and develop solutions to it using market principles.

For more information, visit www.kinshipconservationinstitute.org

Carol Ferrie, Coordinator
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LOTEK WIRELESS FISH & WILDLIFE MONITORING

Company Profile

Lotek Wireless is a world leader in the design and manufacture of fish and wildlife monitoring systems. Our innovative and internationally recognized **radio**, **acoustic**, **archival** and **satellite** monitoring solutions allow researchers to track creatures of almost any size, in almost any environment. Whether an animal moves through a **terrestrial**, **aquatic**, **marine** or **avian** habitat, Lotek has a system to track it.

Leading researchers around the world rely on Lotek equipment and expertise. We are proud to be partners in fish and wildlife research being conducted in more than 35 countries.

Our craft is technology; our passion is the environment. We are committed to providing innovative solutions for a sustainable future. In addition to our leading edge equipment, we also provide environmental consulting services, to assist clients with system selection, research design and implementation, equipment training and data analysis.

Our Products

Simply stated, Lotek makes the most advanced and reliable fish and wildlife monitoring equipment available today. From the traditional to the groundbreaking, we offer researchers a wide range of tracking solutions.

Our systems employ the following technologies:

Radio and Acoustic

Telemetry is the process of conveying information from one location to another. Our telemetry systems include a wide choice of *transmitters* (devices that emit unique radio and/or acoustic signals identifying the animals that carry them) and *receivers/data loggers* (instruments that detect the transmitters' signals and collect and analyze the data received from them). We have taken these technologies in exciting new directions, including:

- combined radio & acoustic tags for mixed habitats (e.g., freshwater/marine or shallow/deep)
- unique coded transmitters that allow large numbers of animals to be tracked on a single frequency
- digital spectrum processor (DSP) technology that allows simultaneous monitoring of multiple frequencies
- remote, off-site monitoring and retrieval of data

Satellite

Our satellite tracking systems use the Global Positioning System (GPS) to record accurate data on the whereabouts of large and small animals in terrestrial and marine habitats. The animal collars are compact, sophisticated devices equipped with radio modems and computer memory modules for data storage and remote transfer of data.

Archival

In fresh or salt water studies where the tracking of species using traditional radio or acoustic methods is not possible, archival (data recording/storage) tags can be used to take light, temperature and depth measurements at regular intervals and store the data until the fish is recaptured. The data can then be used to provide geolocation information. Lotek's archival tag line includes:

- the world's smallest commercially available geolocation archival tag
- deep water tags rated to a depth of 2000 meters
- tags capable of storing more than 6 million data samples for up to 25 years

Locations

Lotek's operations are carried out at two main plants: one in Newmarket, Ontario and the other in St. John's, Newfoundland.

Service

As Lotek's applications arm, Applied Biometrics Inc. (ABI) offers a combination of technological and biological expertise to any consultant or researcher interested in biotelemetry research. ABI's biologists and engineers combine years of experience in fish and wildlife tracking with hands-on expertise in the optimal use of all types of telemetry equipment. Regarded as the "consultants' consultant" in the field of biotelemetry, ABI has assisted in the design and implementation of many important research projects.

Partners

As a strong supporter of the scientific research that biotelemetry serves, Lotek is pleased to be a partner in key strategic alliances with:

The Centre for Environment, Fisheries & Aquaculture Science (CEFAS)

A scientific research centre, CEFAS is the arm of the UK government that is concerned with the conservation and management of related fisheries resources through research of fish behaviour, physiology and reproduction.

Northwest Marine Technology (NMT)

NMT of Shaw Island, USA, has long been recognized for its technological innovation in the science of fish marking. Lotek recently acquired NMT's unique geolocation technology, adding their memory tag to our own growing line of archival products.

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Lotek Wireless Inc. was awarded the ***2002 Canada Export Award for Innovation and Technology Achievement*** *by the Department of Foreign Affairs and International Trade (DFAIC). International Trade Minister Pierre S. Pettigrew (left) and RBC Global Services Vice President Duarte Miranda (right) presented the prestigious award to Lotek's President and CEO, Jim Lotimer (centre), at the Annual Convention of the Canadian Manufacturers and Exporters in Vancouver on October 7, 2002.*

Alpha Mach

Alpha Mach specializes in the design and fabrication of custom oceanographic instrumentation and tooling. We developed the ***iBTag***, a miniature, very low cost data archival tag used for tagging fish and small animal. The ***iBTag***s come in several sizes with a choice of loggers with different resolution, precision and memory. They offer the opportunity to economically tag a large number of fish to get statistically sound results from the returns or to monitor all tributaries of a river for extensive hydrographic surveys.

The ***iBTag*** uses the electronic of the Thermochron[1], a device used extensively in scientific and industrial applications. It is manufactured in high quantities at a very low cost. Alpha Mach has developed an automated process to repackage the electronic in three shapes to resist deep submersion for long periods of time.

First used on Cod in the Gulf of St-Lawrence by Fisheries and Ocean Canada in 2001, the ***iBTag***s are now used in salmon surveys, water temperature monitoring in rivers, lakes and on fish nets in the ocean.

Banner add for Maxim/Dallas Semiconductor site

(http://db.maxim-ic.com/ibutton/solutions/search.cfm)

Text from the Authorized Solution Developers

iBTags are specifically designed and built to be used as temperature data storage tags for fish and small animals. Miniature, light and low cost, iBTags offer the opportunity to economically tag a large number of fish and get statistically sound results from the returns. During hydrographic surveys, rivers and all their tributaries can be monitored for temperature variations at a reasonable cost.

First used on Cod in the Gulf of St-Lawrence by Fisheries and Ocean Canada in 2001, the iBTags are now used on salmon, yellow perch and for water temperature monitoring in rivers, lakes and on fishnets in the ocean.

Available in four sizes with different types of logger specifications. From the larger fish tag to the smallest size: iBCod, iBBass, iBKrill and the iBBat for bat research and other small animals. Custom repackaging is available for specific research. The shape of logger and battery size can be modified to fit particular applications. Custom printing is available on all iBTags.

WT VIII 2004 Exit Survey Summary

Analysis of Questionnaire Responses

We had around 238 attendees for Wild Trout VIII in 2004. Our exit surveys were handed out in the registration kits or provided at the registration table for folks to pick up and turn in prior to the end of the conference. A drawing was offered for a lucky winner (Matt Buhyoff) as enticement to participate. 132 surveys were turned in (55%, down 1% from 2000).

Here are the general impressions, remembering the scale is from 1 (unfavorable or dissatisfied) to 5 (favorable or satisfied).

Overall Impression:

	Rank	Indication	Responses
Meeting date	4.4	**Favor**	131
Meeting location	4.8	**Favor**	132
Topics covered	4.1	**Favor**	128

These are the highest ratings on record

Meeting scheduling:

- Keep the same days (M-W) same — 110 (83%) for keeping the schedule the same
- Different season — Of 37 responses commenting on season, 25 (68%) cited Fall as the best time.

This level of satisfaction is almost identical to 2000 (83% for keeping the same, 78% for moving to Fall)

Meeting location:

- Suggestions from the 7 comments on a different meeting location included choosing a university site, a site out of the national park, or simply providing better meeting and lodging room facilities (more heat, better bathrooms).

Meeting Facilities:

	Rank	Indication	Responses
Meeting room	3.6	**Good**	130
Audio visual	4.3	**Good**	131
Computer equipment	4.3	**Good**	109
Sound System	4.1	**Good**	130
Other (food, breaks, housing)	4.2	**Good**	130

This is a great improvement over 2000 – with the reminder, however, that meeting room facilities are still too cold (78% of unfavorable comments were about room temperature). Though folks appeared to be impressed with our improvements in technology, 18 comments were received about providing a better sound system (mobile mikes and at meals) and bigger screens. Having mobile mikes available for audience participation was frequently mentioned.

NOTE: As in 2000, responses were strongly supportive for maintaining meeting site in Yellowstone National Park; citing atmosphere, fishing opportunities as benefits.

Areas for needed improvement:

Facilities – better heat or remind about need for warm clothing
Technology – provide more sound system components; consider providing Internet access/office, presentation design standards
Publicity – reach out to International community, agenda updates on web page

Participant resource interest/Satisfaction:

The survey asked participants to rank their interests in the following topics and how satisfied they felt WT-8 met those interests.

	Interest	Satisfaction
Fishing	2.6	3.2
Fish management	3.9	4.1
Habitat protection	3.9	3.8
Resource advocacy	3.3	3.8

♦ Resource conservation	3.8		4.0
♦ Other interests	3.8		4.0
(Angler participation, Base ecology, basic science of wild trout, Communication, Education, Fish ecology/science/biology, Fish rehabituation, Habitat restoration, Historical perspectives, How to gain public support, I&E techniques, Innovation, Invasive species w/native species, Macro-invertebrates, Negotiations and public perception, Partnerships and collaboration, Planning, Public education, Research, Social/philosophical issues, Technical issues)			
♦ Interests met by WT-8	4.1	**Yes**	4.1

Planning Ideas for WT-9 (Possible Topics, Ideas)

	Interest
♦ Fishing Methods, Techniques	2.4
♦ Fish Management	4.1
♦ Angler Advocacy	3.8
♦ Panel Discussions	3.5
♦ Point-Counterpoint issues	3.6
♦ Technical Research Talks	4.2
♦ Public Education, Resource	3.9

NOTEWORTHY COMMENTS:

Facilities and Content:

These are from WT-7's survey results and they still apply to WT-8. "The majority of critical comments with respect to the meeting facilities addressed lack of an effective sound system and inefficient heating. While the atmosphere and pleasures of attending a meeting located at YNP are great. The rankings of WT-7 (and WT-8) were very similar to WT-6, including the references to not including more angling public and non-professionals."

Organizational suggestions:

A redesign on the survey should be considered prior to WT-9. People are still confused by ranking the value of a topic and then rating degree to which topic was presented. Also, the topics need to be revisited.

Suggested for WT-9 – what worked and what didn't:

- Hand out evaluation at end of meeting to catch more spontaneous and relevant ideas - worked
- Written logistics – **continue to develop**
- Announcements posted by coffee – ***worked***
- Larger lettering on nametags – no complaints issued - ***worked***
- Photographs taken after talks – better effort made, could formally assign student or photographer to ensure high quality images - **continue to develop**
- Sign on podium saying meeting name - ***worked***
- Acknowledgement of sponsors – by signage and presence in meeting room; very appreciated by vendors - ***worked***
- Completed updated list of attendees – has yet to come out; many participants requested them at the meeting, rather than after the fact – **didn't work**
- Emphasis on improving quality of presentations (especially visuals) – still have issues with PowerPoint design - **didn't work**
- Give more down time to allow for mini-meetings or a trip to see wolves with John Varley – offsite trips (Lake trout trip on Yellowstone lake, tour of facility) disorganized and hard to administer - **continue to develop**

Topics included as session possibilities:

Comments were offered as topics across a wide range of subjects, while others addressed the symposium as a whole. These general comments are categorized broadly below.

Agency/Collaboration

- How can state fishery agencies best manage and foster wild trout fisheries? (organized and presented in a way that encourages states with deficient programs to do better - in some states, the fishery programs are deteriorating severely). How streams undergo self-restoration of trout habitat (a session involving geomorphologists and riparian vegetation experts)
- More management, less research. Not enough agency managers and heads, not enough politicians - more keynotes - Cecil Andrus, Nat Reed, etc.
- More habitat specific issues may be possible. Also, more promotion of WT-9 in UK/Europe to increase international component and participation/collaboration could be a good thing?!
- Public lands are critical to wild trout. I was disappointed by low attendance from US Forest Service. Regional and national FS

leaders need to have a presence and encourage more FS Bio's to attend.

- This year was too strong on research. Need more management - administrators, politicians, laymen (anglers).

Biology/Science/Habitat

- Consider education section on specific topics. This group could perhaps benefit from an overview of genetics, trout life history, *I.e. comparison of native and introduced) or other specific topics.
- Genetic and biodiversity conservation
- Depends on what's 'hot' at the time. I'd like to see a discussion on habitat "improvement" vs. natural restoration, although maybe better topic for stream habitat workshop.
- Does healthy watersheds lead to healthy native fish populations or just to healthy fish populations?
- Good presentations on the writing aspects beyond technical report staff. For WT-9, there could be more specific discussion on barriers, largewood and habitat partitioning by species or assemblages. A more inspirational keynote would be good. Ted Turner was interesting, but was not too prepared to hit home the overall message of wild trout.
- Have a Rosgen vs. non-Rosgen habitat restoration debate! Are managers using more habitat protection and restoration techniques to manage fisheries? If yes, what techniques are they using, what methods are they using to measure success, how are they defining success and what have they found that works or doesn't work.
- Studies of habitat/stream restoration on wild trout; effective techniques in stream restoration and habitat enhancement.
- Would like to see younger biologists/students attending. Would like to see WT-9 build upon Amy Hargis idea of innovative restoration techniques as a session. It would be neat to have had a panel discussion in the reality vs. expectation session, including presenters and some state commissioners....hmmm!
- Need more bug talks. I really liked session #2.

Ethics

- Angler ethics, stream restoration and watershed restoration and conservation - re-introduction of natives. Same old stuff I guess.
- We who are involved in wild trout eagerly listen to the professional ecologists, limnologists and other scientists but when it comes to ethics, we regard ourselves as authoritative! We're not. We're amateurs, and most of our pontificating about 'ethics' is usually just about manners. Shouldn't we engage the environmental ethicists and philosophers? Maybe it's too scary?

Meeting/Agenda procedures

- A general access computer for Internet service would be great.
- Biologists tend to have some disagreements whether it's due to agency missions, personal value systems or technical approaches. Pt/counter-Pt. discussion of contention issues would be valuable.
- Committee doing good job!
- Fisheries management and incorporation of resource strategies into comp use planning (USFS, BLM, BOR, Tribes) for protection/enhancement.
- Get attendee list out early. Try to introduce attendees - I.e. ask for show of hands for areas and professional responsibilities - "who's looking for a job?" etc.
- Great job overall! Please make lunch programs relevant to all participants - limit moderators/speakers to 5 mins succinct introduction/presentations.
- I just wanted an overview of the event and to meet people and hear about their work and interests. It was great.
- I thought the panel discussions were valuable opportunities for attendees to explore items of interest w/speakers. Be sure to include these in WT-9. We obviously need more information/discussion about communication and angler education. Exotic species, invasive species and their effects on native trout. Trout effects on other organisms (herps, inverts, non-salmonids) should also be a point of discussion. Trout, even wild trout, are not always appreciated!
- I would like to see a more expanded trade show - fishing gear, etc. I don't like standing in line.
- I would prefer to have talks limited strictly to 15 minutes with 5 minutes for questions. At this meeting few questions could be asked. Also, question should be immediately asked, rather than as a panel later in the session.
- I'm sure you hear this every year but a warmer room would be nice. More time after each talk for questions would be beneficial. I enjoyed having a set time/place for the poster session.
- Maintain focus on wild trout management and especially development of partnerships and funding from non-traditional sources.
- More attention to keeping speakers on time, allow for questions from the audience. Would also like to see active encouragement of interaction between speakers and

audience. This was an excellent agenda, the best in the last 4 meetings.
- Next time, provide an updated version of PowerPoint.
- Organize abstracts portion of program in the same sequence as the speakers. Include first names of speakers, not just initials.
- Panel discussions need conflicting positions.
- Panel discussions should have more discussion time and less introductory time.
- Possibly a little more free time in afternoons? Start dinner a little later?
- Provide an attendee list w/emails & phone #s. Please include a wider variety of species talks - more bull trout, grayling, and native rainbow/steelhead. Provide hands on topics, maybe provide a day for collection of field data to help w/ an un-funded project/monitoring (i.e. similar to the salvelinus confluentus curiosity society)
- Provide ordering of high quality fishing shirt (like the ones the committee wore this year) on registration form. Probably a different color than planning committee so we can tell who is on the committee. Special planned activities for families. Possible special trip for attendees. Repeat performance of "Troutball.com".
- The entertainment by Greg Keeler was great. More of that!
- We need more attendees under 40 and under 30 - having the student chapter of MSU-AFS was great. How about extending this to Idaho, Wyoming or other student chapters?
- Checking the Internet up to a few weeks before the meeting, I couldn't't' find an agenda yet available. With more lead-time, you might be able to draw more participants.

Population dynamics

- A point-Counterpoint debate about invasive species (fish, plants, etc). How to eradicate, versus waste of time.
- Dedicate a session to the latest research on the mechanisms involved in replacement of native trout by non-natives, and all trout by non-trout species.
- Fish population management vs. individual fish management.
- More debate on the seminal topic - what should be done about planted fish?
- Resident vs. anadromous forms of O. mykiss and O.c.clarkii and how they interact and implications for management and species listing decisions. Strongly suggest T-shirt sales with logo on it as keepsakes and fundraiser.

Public

- A bit more of a mix w/issues of concern of public
- Although generally not interest in the topic of fishing (methods/techniques), it appears that WT has become another professional meeting, very low interactions with anglers.
- Considering the nationwide decline in fishing participation and in particular the East Coast, a strong focus on increasing fishing participation, marketing strategies, public outreach events aimed at introducing non-anglers to fishing, increasing resource awareness to non users, and resources available for marketing, cooperative projects. Participation affects so much of what we do (research, mgmt, budget, politics) if we could improve could have better resources for research and mgmt activities.
- Find ways to get input/participation from anglers - organized and unorganized.
- Fisheries outreach - how to communicate our messages.
- How do we reach the silent majority? Getting better stakeholder participation. Hold fly- casting clinic for those that do not already fly fish. This could be held Sunday AM before registration.
- I am one of the non-biologist/scientist attendees. We are a distinct minority and I perceive without a voice. I recognize the need for professional representation but not as heavily weighted as it is. This was also true at WT-7 which I attended. You need to expand your involved communities to include non-scientific government, outfitter/guide community, land owners, anglers.
- It would help a lot for more people to learn how to fish, rather than keeping it a closed knit group sport. We need an engaged public if there is to be a future. Maybe have workshop sessions on how to fish, say Yellowstone waters? Not only continue, but increase focus on communicating fisheries issues to the public and on engaging stakeholders in the decision making process.
- Perhaps a greater engagement with international "trout-interested' community? Whether this could be accomplished by wider advertising or not I don't know - just a suggestion.
- Strategies for dealing with public controversy over using piscicides to restore native trout.
- Throw in some fishing technique/methods to spice up a session, better yet, give a trip away! More about teaching to the public. It was probably in your literature and I missed it but an advisory to bring warm clothes and hat and gloves would be good.

Technology

- Trout biology, technical research methods e.g. coded wire, telemetry, etc.

Wild Trout

- If it hasn’t happened yet, then there should be a panel discussion about the need for regulations requiring anglers to have passed a fish identification test before they are permitted to harvest fish in waters where native salmonids are found.
- More historical perspective of fish management, special regs, research projects, etc. Example: Several questions were directed to Jacklin about native fish and he kept answering in terms of wild fish as if that was the question… that indicates that he (and probably others) equate them equally. Let's expand on that.
- Native fish vs. wild fish - I still don't think Bob Jackson understands that rainbow and brown trout aren't native fish. Let's hear from the angling public on what would get them to support native fish restoration programs. Also, how are we going to deal with ANS?
- Urbanization and maintaining wild trout fisheries
- Urbanization/sprawl effects on wild trout habitat in privately owned lands. (groundwater withdrawal; % impervious surfaces; competition; etc.) Fish passage - restoration of habitat. Status of wild trout - all (focus of WT-8 seemed to be brook and CT; try to include grayling, goldens, bull trout, DV etc, next time)

Past Participants in Wild Trout Symposiums

SECOND NAME	FIRST NAME	WT-I 1974	WT-II 1979	WT-III 1984	WT-IV 1989	WT-V 1994	WT-VI 1997	WT-VII 2000	Comment
SPEAKERS/PANELS:									
Abele	Ralph	X							
Adams	F. Jeffrey					X			
Alexander	Gaylord R.			X					
Anderson	Richard			X					
Andrews	Rupe		X						AK
Arnnett	G. Ray			X					
Avery	Ed		X						
Ayerst	Jack	X							
Baake	Bill M.					X			
Barnhart	Gerald A			X					
Barnhart	Roger	X	X						
Baughman	John			X					
Behnke	Bob		X		X			X	Colo State U
Bergin	Joseph D.			X					
Bielak	Alex				X				
Bjornn	T.C.			X					
Borawa	James							X	
Borgeson	Dave	X							
Brewin	MK						X		Canada, TU
Britt	Douglas				X				
Brooks	JE							X	
Brown	James				X				
Burnha, Curtis	Mary K						X		
Burrows	Chuck		X						
Burton	Gerald						X		
Butler	Bob	X							
Calhoun	Alex	X							
Cartwright	John				X				
Chapman	D.W.				X				
Clancy	Chris						X		
Clark	Richard D.			X					
Congleton	Joe	X							
Corsi	Charles							X	
Crowell	John B.			X					
Davis	J. Scott						X		
Dienstadt	John M.			X		X			CA
Dolloff	C. Andrew					X	X	X	
Dompier	Doug		X						
Duff	Don		X					X	
Dwyer	Wm. P.					X			
Edmonson	Jim						X		
Elmore	Wayne				X				
Engstrom-Heg	Robert E.			X					
Eshenroder	Randy				X				
Esierman	Fred		X						
Fedler	Anthony					X			
Fetteroff	Carlos M.			X					Gt Lks Commission
Fjelsted	Sigurdur			X					Iceland
Flebbe	Patricia						X		
Ford	Richard			X					
Forsgren	Harv					X			
Fox	Douglas								
Franco	Rebeca						X		
Gamblin	Mark						X		
Gebhards	Stacy	X							
Graff	Delano R.			X	X				
Graham	Dick	X							
Graham	Patrick				X				
Grant	Gardner	X		X					
Greenley	Joseph C.			X					
Greib	Jack		X						

SECOND NAME	FIRST NAME	WT-I 1974	WT-II 1979	WT-III 1984	WT-IV 1989	WT-V 1994	WT-VI 1997	WT-VII 2000	Comment
Gresswell	Bob		X				X		
Grost	Richard T					X	X		
Haimes	Terry A.			X		X			
Hammel	Rick						X		
Hammer	Rebecca				X				
Hanson	James				X				
Harig	Amy						X		
Heede	Burchard H.			X	X				
Helm	Bud	X							
Hough	John		X						
Hudy	Mark				X				
Hulett	Patrick				X				
Hunt	Robert L.	X				X		X	
Imhoff	Jack					X	X		
Jackson	Robert				X				
Jennings	Bob		X						
Jones	Ron		X	X					
Kauffman	Nancy					X			
Kiefling	John W.			X					
King	Willis	X		X					
Knox	William J							X	
Knuth	Barbara					X			
Kochman	Eddie		X						
Kutkuhn	Joe		X						
Lantz	Dick	X							
Liknes	George				X				
Lilly	Greg		X						Angler
Long	Michael							X	
Lohr	Samuel							X	
Maharaj	Vishwanie						X		
Mahony	Daniel						X	X	
Maranick	Jerry					X			
Marcoux	Ron		X						
Martin	Jim					X			
McClelland	Pamela			X				X	
McFadden	Jim	X							
McNall	Warren	X							
Minard	Eric				X				
Mitro	Matthew						X		
Mongillo	Paul			X					
Moore	Steve				X				
Morgan	Raymond						X		
Morgens	Linda			X					Conservationist
Nankervis	James					X			
Neckels	Jack			X					
Nehring	R. Barry				X		X	X	
Nelson	John			X					
Netsch	Norval			X					AK
Newman	Lee F.						X		
Nicholas	Jay				X			X	
Nickum	John		X			X	X		
Nielsen	Jennifer						X		
Nolte	David					X	X		TU
Novak	Mark				X				
Pardue	Garland		X						
Parker	Nick					X			
Parmenter	Steve							X	CA F&G
Peterman	Larry					X			
Petrosky	C.E.			X					
Petterolf	Carlos			X					
Pfitzer	Don	X							
Platts	Bill		X						
Proebstel	Don					X	X		
Putz	Robert E.			X					

SECOND NAME	FIRST NAME	WT-I 1974	WT-II 1979	WT-III 1984	WT-IV 1989	WT-V 1994	WT-VI 1997	WT-VII 2000	Comment
Quinn	Steve								Ed.Mag. An. Rights
Raleigh	Bob		X						
Reed	Nathaniel P.	X	X						Ass't Sec. Interior
Reiger	Henry		X						
Remmick	Ron					X	X		
Richardson	Frank			X					
Rinne	John		X						
Robinson	Christopher				X				
Roelofs	Terry D.			X					
Roghair	Craig							X	
Romeo	Nick, Mary							X	Fintrol
Ruzycki	James						X		
Schill	Dan						X		
Schpck	Susan						X		
Schofiels	Carl		X						
Schreck	Carl		X						
Seehorn	Monte E.			X					
Seldon	Marty		X						Angler
Seymour	Stephen						X		
Shake	Bill					X			
Sharpe	WE							X	
Shepard	Bradley B.			X					
Shuizawa	Dennis					X			
Shum	Benny							X	
Shupp	Bruce			X					
Silvey	Jill						X		
Sorg	Cindy F.			X					
Soverel	Pete						X		
Stark	John							X	
Stefferud	Jerome A.			X					
Stolte	Larry		X						
Stumpf	William						X		
Talleur	Richard					X			AnglerAuthor Lunch
Taubert	Bruce D.			X					
Taylor	Gerry		X			X		X	
Thrush	William J.				X				
Thurow	Russ			X		X			
Trotter	Patrick C.			X					Angler
Turner	Spencer			X					
Van Gytenbeek	Pete		X						
Van Kirk	Robert						X		
Vincent	Dick	X		X					
Wada	Lorena					X			
Watson	Gordy		X						
Watt	Walton D.			X					
Webb	J.R.				X	X		X	
Webster	Dwight	X							
Wells	Jerry			X					
Werdon	Selena							X	
Wesche	Thomas				X				
White	Ray J.	X				X			
Whitney	Art	X							
Wiley	Bob	X			X				
Williams	Thomas						X		
Wiltshire	Bob						X		
Wilzbach	Peggy							X	
Woodworth	Dick		X						
Young	Michael					X			
CHAIRMEN:									
Richardson	Frank	X	X	X	X				A. Reg Dir F&WS
Van Gytenbeek	Pete	X							XPres FFF, ED TU
Grant	Gardner		X	X					XPres FFF
Owen	Mike		X	X					Xpres TU
Barnhart	Roger					X			CCU

SECOND NAME	FIRST NAME	WT-I 1974	WT-II 1979	WT-III 1984	WT-IV 1989	WT-V 1994	WT-VI 1997	WT-VII 2000	Comment
Jones	Ron					X			YNP
Dwyer	Pat						X		MT
Byorth	Pat							X	MT
Moore	Steve								Chairman WT-VIII
ORG/PLANNING COMMITTEE:									
Anderson	Jack	X							Suptndnt YNP
Barnhart	Roger			X					
Duff	Don						X	X	Fund Raising
Grant	Gardner			X					
Loveleess	Charlie				X				
Mamer	Liz							X	Technical Supt
Owen	Mike			X	X				
Peters	John	X	X	X					
Richardson	Frank	X	X	X					
Seldon	Marty		X	X	X	X	X	X	
Townsley	John		X						YNP
Urbani	Joe			X	X	X	X	X	Treasurer
Van Gytenbeek	Pete	X	X						
PROGRAM:									
Amato	Frank	X							
Bakke	B.M.	X							
Barnhart	Roger			X					
Byorth	Pat							X	
Dolloff	Andrew						X		
Duff	Don					X			
Gresswell	Bob						X	X	Chair-6
Hooten	Bob							X	
Hulbert	Phil					X	X		
Hunt	Joel						X		
King	Willis	X	X						
Lentz	David						X	X	
Loveless	Charlie			X					
McCelland	Pam					X			
McGurrin	Joe					X			
Moore	Steve						X	X	Cochair-7
Noble	Sandra						X	X	
Owen	Mike			X					
Pendergast	Linda						X		Poster-Chair
Peters	John		X	X					
Richardson	Frank	X	X	X					
Seldon	Marty			X			X	X	
Shake	Bill					X			
Schill	Dan							X	Cochair-7
Van Gytenbeek	Pete			X					
Van Gytenbeek	Susan					X			
Wiley	Bob					X	X	X	Cochair-6
EDITORIAL:									
Amato	Frank	X							
Bakke	Bil M.	X							
Byorth	Pat							X	
Hamre	Bob			X	X	X	X	X	
King	Willis	X	X	X					
LoSapio	Carol							X	
Loveless	Charlie								
McGurin	Joe					X			
Moore	Steve							X	
Peters	John		X						
Raver	Duane			X					
Richardson	Frank	X	X	X	X				
Riedel	Mike		X						
Ripley	Scott			X					
Schill	Dan							X	
PHOTOS:									
Emerald	Neal					X			

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Pero	Tom		X		X				
Seldon	Marty		X	X	X	X	X		
Yuskavich	Jim				X				
Turner	Spencer						X	X	
LOGISTICS:									
Alson	Joe					X			
Anderson	Sonya					X			
Barbee	Bob (Chair)			X					
Barnhart	Roger			X					
Dwyer	Pat						X		
Byorth	Pat							X	
Jones	Ron			X					
Grant	Gardner			X					
Green	Lori			X					
Kseding	Lynn					X			
Owen	Mike			X					
Richardson	Frank			X					
WEB PAGE:									
Black	Wayne							X	MT
NOTABLES/HEADLINERS/KEYNOTERS:									
Abrams	Rev. Dan			X					Banquet Speaker
Anderson	Jack	X							
Arnett	G. Ray			X					A. Sec Interior
Babbitt	Bruce					X			Sec. Interior
Barbee	Robert				X				YNP
Brouha	Paul					X			AFSBanquetSpeakr
Carter	Wilfred	X							ED AtSalFedCanada
Crowell	John			X					
Donnelley II	Thomas E.				X				Trout & Sal Found
Dysart	Benjamin C.			X	X				Ex Dir NWF
Finley	Michael V.						X		Suptndt YNP
Franco	Rebeca							X	
Gauvin	Charles F.					X			Ex Dir TU
Hair	Jay H.					X			Ex Dir NWF
Herbst	Bob		X						USF&WS
Holloway	Ron J.						X		UK Riverkeeper
Leopold	Luna B.				X				Prof
Leopold	A. Starker	X	X						Prof
Luch	Bill	X							Pres TU
McGuane	Thomas							X	Banquet Speaker
Perkins	Perk						X		President, Orvis Lunch Speaker ?\
Reed	Nathaniel P.	X	X	X	X				Keynotes
Rose	James D.							X	Lunch, Fish Pain
Schullery	Paul						X		Banquet Speaker
Schwiebert	Ernie				X				Banquet Speaker
Townsley	John	X	X						Suprntdnt YNP
Varley	John	X	X		X	X			YNP Res. Chief
Wade	Karen							X	NPS Reg. Dir
Wulff	Lee		X						Author, Angler, Icon
SUMMARIZERS:					?				
King	Willis	X		X					
Leopold	A. Starker		X						
Martin	Robert					X			
Turner	Spencer						X		
Wiley	Robert							X	
COVERS:		?				?	?		
Stidham	Mike		X						
Raver	Duane			X					
Cruwys	Roger				X				
Mimi	Matsuda							X	
AWARDS CHAIRMAN:		--	--						
Barnhard	Roger			X					

SECOND NAME	FIRST NAME	WT-I 1974	WT-II 1979	WT-III 1984	WT-IV 1989	WT-V 1994	WT-VI 1997	WT-VII 2000	Comment
Van Gytenbeek	Pete				X	X			
Seldon	Marty							X	Also WT-8
Richardson	Frank			X			X		
A.STARKER LEOPOLD AWARDEES:									
Behnke	Bob	-	-	X					
Seldon	Marty	-	-	X					
Richardson	Frank				X				
Teller	Otto				X				
Jones	Ron					X			
Grant	Garnder					X			
Barnhart	Roger						X		
Schwiebert	Ernie						X		
Hunt	Robert L.							X	
Lilly	Bud							X	

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The Wild Trout VIII symposium was very successful. The conference had 210 pre-registrants from across the United States, Canada, Australia, and England. During the conference, 36 papers were presented; lively panel sessions followed some of the presentations. Many of the attendees and members of the original founding committee commented that this was the best meeting in the 30-year history!

Steve Moore,
Symposium Chairman

Wild Trout VIII

30th Anniversary

Working Together to Ensure
the Future of Wild Trout