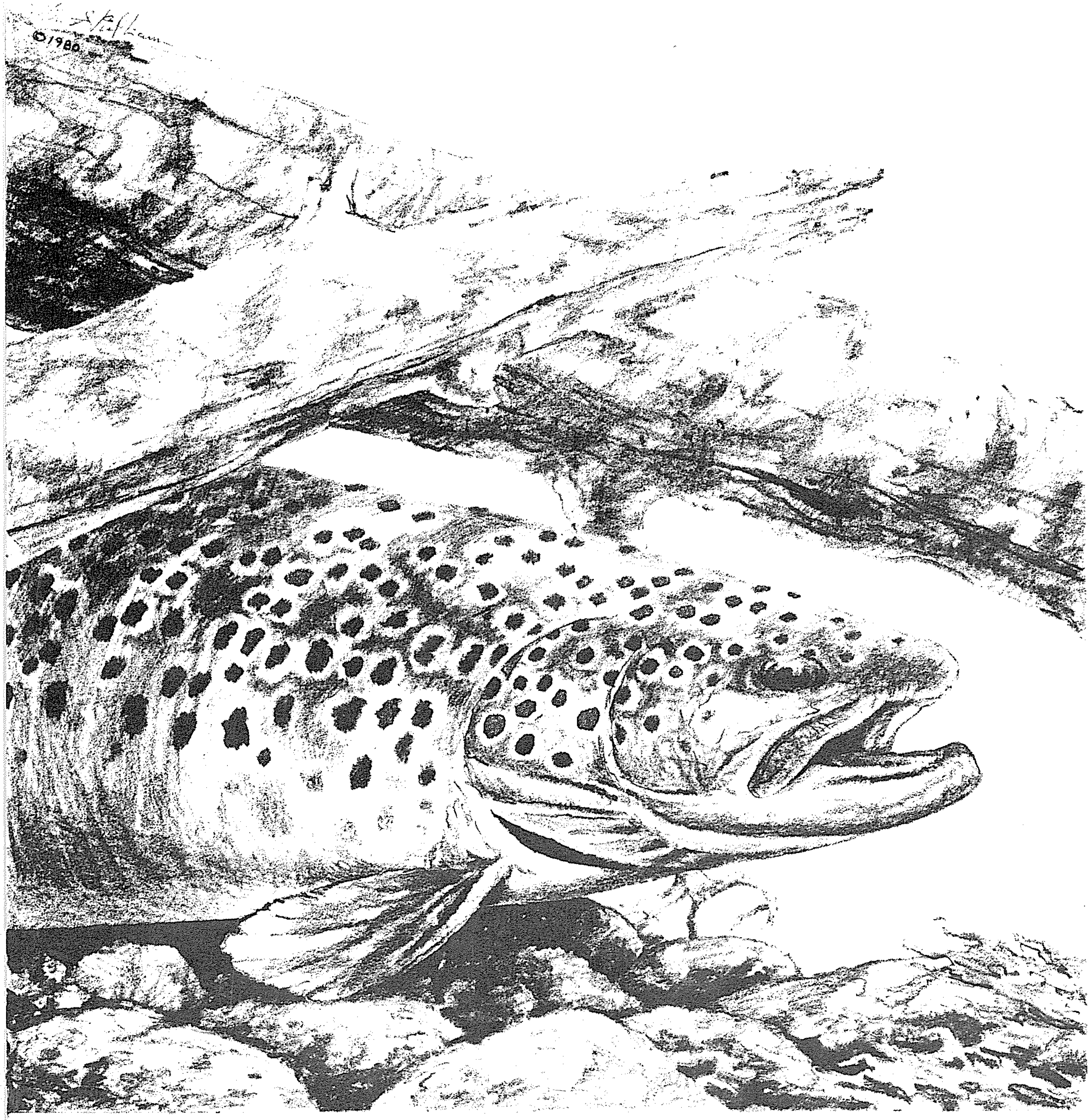
WILD TROUT TWO



PROCEEDINGS

OF

WILD TROUT II

YELLOWSTONE NATIONAL PARK

SEPTEMBER 24-25, 1979

SPONSORED BY

TROUT UNLIMITED

FEDERATION OF FLY FISHERMEN

U.S. DEPARTMENT OF THE INTERIOR

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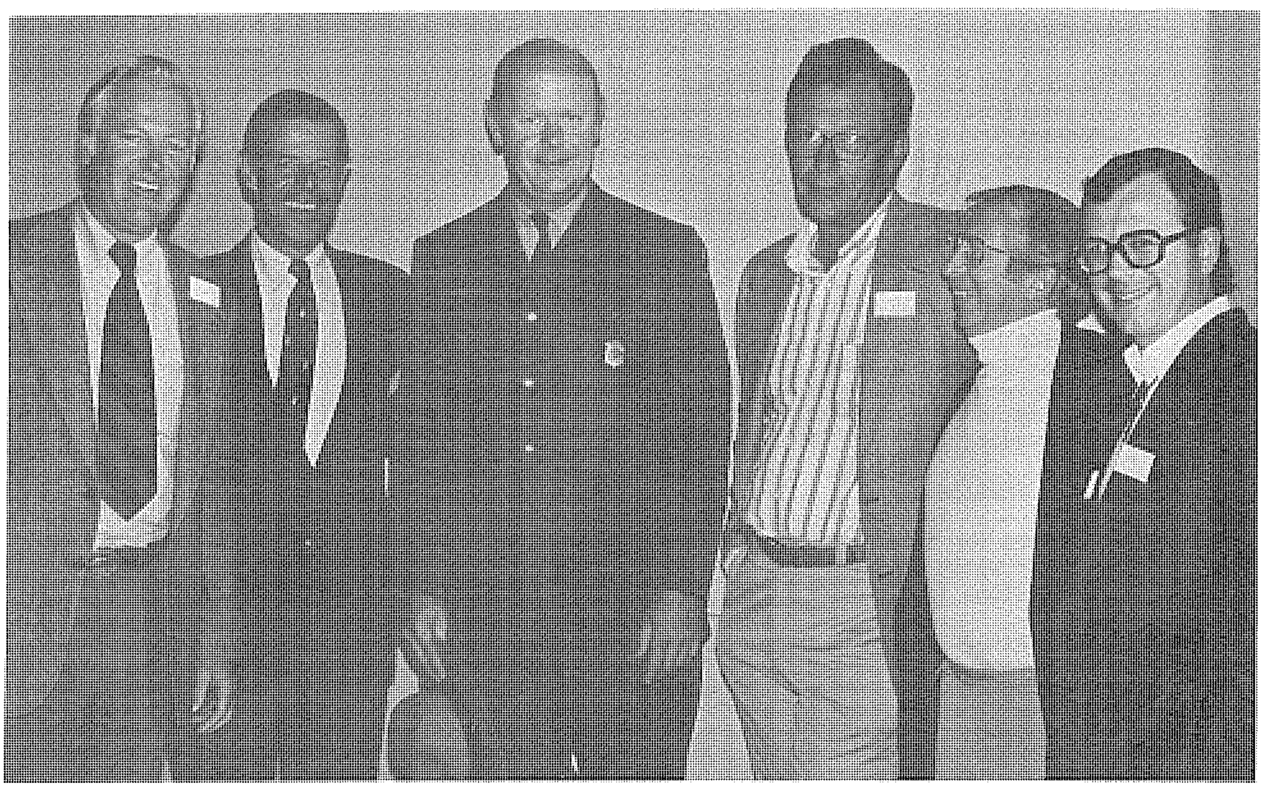


INTRODUCTION

The idea of holding a second Wild Trout Symposium was first called for in the closing remarks of then Assistant Secretary of the Interior for Fish and Wildlife and Parks, Nathaniel P. Reed, in Yellowstone National Park in 1974 at the first international Symposium which was co-sponsored by Trout Unlimited and the Department of the Interior. In 1977 at the Annual Conclave of the Federation of Fly Fishermen, the President of the Federation of Fly Fishermen and the President of Trout Unlimited reminded Robert L. Herbst, Assistant Secretary of the Interior for Fish and Wildlife and Parks, the Conclave Keynote Speaker, of that challenge laid down by his predecessor. At that Conclave Secretary Herbst accepted the challenge. He designated Frank Richardson of the U.S. Fish and Wildlife Service to represent his office. Gardner Grant, then President of the Federation of Fly Fishermen, and Mike Owen, then President of Trout Unlimited, took it upon themselves to represent their organizations. These three became the core group in the planning of Wild Trout II. Richardson became Chairman; Grant and Owen, Assistant Chairmen. They quickly added to their team John Townsley, Superintendent, Yellowstone National Park; John Peters, Environmental Specialist, Water and Power Resources Service; and Pete Van Gytenbeek, a National Director of Trout Unlimited and its former Executive Director. Later Willis King, retired U.S. Fish and Wildlife Service, was asked to be the Editor of the Proceedings. Richardson, Peters, Van Gytenbeek, and King were principal participants in the organization of the first Symposium.

If credit for the ideas, the invitation of the speakers, the program organization, the logistics arrangements, editing of the Symposium, publicizing, finding a publisher, and the endless details and little jobs is given--these individuals identified above may take the accolades.

Particular credit must be given to Mike Riedel, Federation of Fly Fishermen member from California, who located the principal sponsor for publishing the Proceedings, and who did yeoman work in finalizing this finished product.

Our photo credits go to Tom Pero, Editor of Trout, and Marty Seldon, Executive Vice President of the Federation of Fly Fishermen. We believe these will add to your enjoyment, rather than detract from the reading of the technical papers.

However, the true credit for the success of the Symposium is to the biologists, the anglers, the students, the teachers, the writers, the managers, the administrators, the conservation leaders--from every trout region of North America, all interested in Wild Trout, who came and participated. They participated in the formal sessions as speakers, commentators, and debaters; they talked in the hotel lobby, rooms, and cabins; they talked on the banks of the Yellowstone's famous trout waters; they talked in autos and planes coming to and leaving Yellowstone; they talked at every opportunity about Wild Trout.

SUMMARY - WILD TROUT SYMPOSIUM II[1]

A. Starker Leopold[2]

There are three components in maintaining a trout fishery: (1) managing the fish and the fishery; (2) managing the water in which the fish live; and (3) managing the watersheds which yield the water in which the fish live. I went over my notes of the transactions of this meeting and roughly categorized the individual presentations into these areas of emphasis:

15 of your papers dealt largely with managing fish and fishermen,

6 considered water itself--pollution control, adequacy of flows, mitigating ill effects of dams and blockages, etc.,

3 concerned primarily watershed problems.

This breakdown is in no way surprising. Most of us are in positions that call for managing or studying fish, or the water in which they live. We are not responsible for managing the whole landscape. Someone else decides how many cows to run in a given watershed, where and how many trees to cut, what sort of road system should be built, where towns and subdivisions should be situated, and what to do with sewage effluent or mine tailings or the drainage from dairy barns. Yet these decisions are crucial in the maintenance of productive trout streams. The management of the trout resource cannot be dissociated from management of the watershed resource, and this truism was recognized repeatedly during the conference. Hopefully, relevant research will follow.

I was pleased to note two additional themes that emerged again and again in the papers and in the discussion periods that followed. One concerned the importance of genetic adaptations in strains of trout. It seems to me that a very few years ago fisheries managers tended to think that "a trout is a trout is a trout" and genetic lineage did not make much difference. Today we know that to be far from the truth. Locally adapted populations have great ecologic advantages. Secondly, there is growing concern to preserve the quality of the fishing experience, vis-a-vis the quantitative measure of the full creel. Lee Wulff and many others elaborated this basic truism, to which I am sure all of us subscribe.

As regards the majority of papers that concerned trout or their immediate aquatic environs, I may say that we have been privileged to hear some outstanding reports in these two days. I cannot begin to do justice to all of them, but I would single out a few for specific comment. Going back again to my boyhood in Wisconsin, I am more than a little perplexed by the deterioration of the brown trout fishery, and virtual disappearance of brookies and rainbows in the Mecan River, as recounted in Avery's paper. I want Ed to know that I kept a diary when I fished that stream in the 1930's, and those big fish I remember so well were measured, with a ruler, and duly recorded. If these data would be of use, I will try to dig them up. I cannot believe that fishing has induced the changes described by Avery. There must have been subtle changes in the stream itself, induced somehow by land use practices. At least that possibility should be considered.

In earlier years, I spent summers in Door County, Wisconsin, where I well remember the boatloads of lake trout coming to dock each evening, on the way to the Milwaukee market. Kutkuhn's account of the current effort to restore that fine fishery and the multiple problems encountered I found fascinating, though a bit discouraging. Speaking of pollution, the acid rain described so graphically by Schofield is horrifying in its prospect. If indeed this atmospheric scourge spreads and intensifies, as it appears to be doing, I can envision an environment that not only is devoid of fish life but is scarcely habitable for man. The brave effort to restore Atlantic salmon, as recounted by Stolte, could be just one of many fruitless endeavors to recreate native fisheries in our northeastern seaboard.

The similarities of fisheries problems in Alaska and British Columbia were well represented by Andrews and Taylor. For those of us who live in heavily populated states, it would be a joy

[1]Paper presented at the Wild Trout II Symposium, Yellowstone National Park, Wyoming, September 24-25, 1979.

[2]Emeritus Professor of Zoology and Forestry, University of California, Berkeley.

to confront the elegant problems of maintaining fishing quality in the wilderness waters of the Northwest. Of all the rivers I have fished with a fly, I think the pursuit of steelhead in the Dean River is the peak of my fishing experience. It is a cheerful thought that through foresight and good judgement these magnificent runs can be maintained.

Of maximum interest to me were the reports of Marcoux on the Madison River studies and of Jones, Varley, et al. on the Yellowstone Lake and Yellowstone River cutthroat fisheries. Both of these studies give us solid data on the gains and limitations afforded by catch and release fishing. As regards the Yellowstone complex, it is a source of great personal gratification to see the results of catch and release regulations on the River between Yellowstone Lake and the Great Falls. When I started fishing that River the daily limit was three, and since no license had to be purchased, it was common for fishermen to lay in a supply of fish on ice, counting three for the wife, three for each kid, three for grandma, and so on. Sometimes if no ice chest was available, the fishermen would simply dump spoiled fish in the garbage cans, which aggravated an already difficult bear problem. I can well remember Jack Anderson, former Superintendent of Yellowstone National Park, stewing over this situation, gathering his courage to institute no-kill regulations on the River, and then to close Fishing Bridge. That he did so is a credit to Jack's guts, thereby perpetuating a magnificent fishery for the wonder and enjoyment of the American public. The data now being gathered by the Yellowstone fishery team clearly endorse Jack's foresight and judgement. I hope that the team will be amply supported for continued studies of this superb resource.

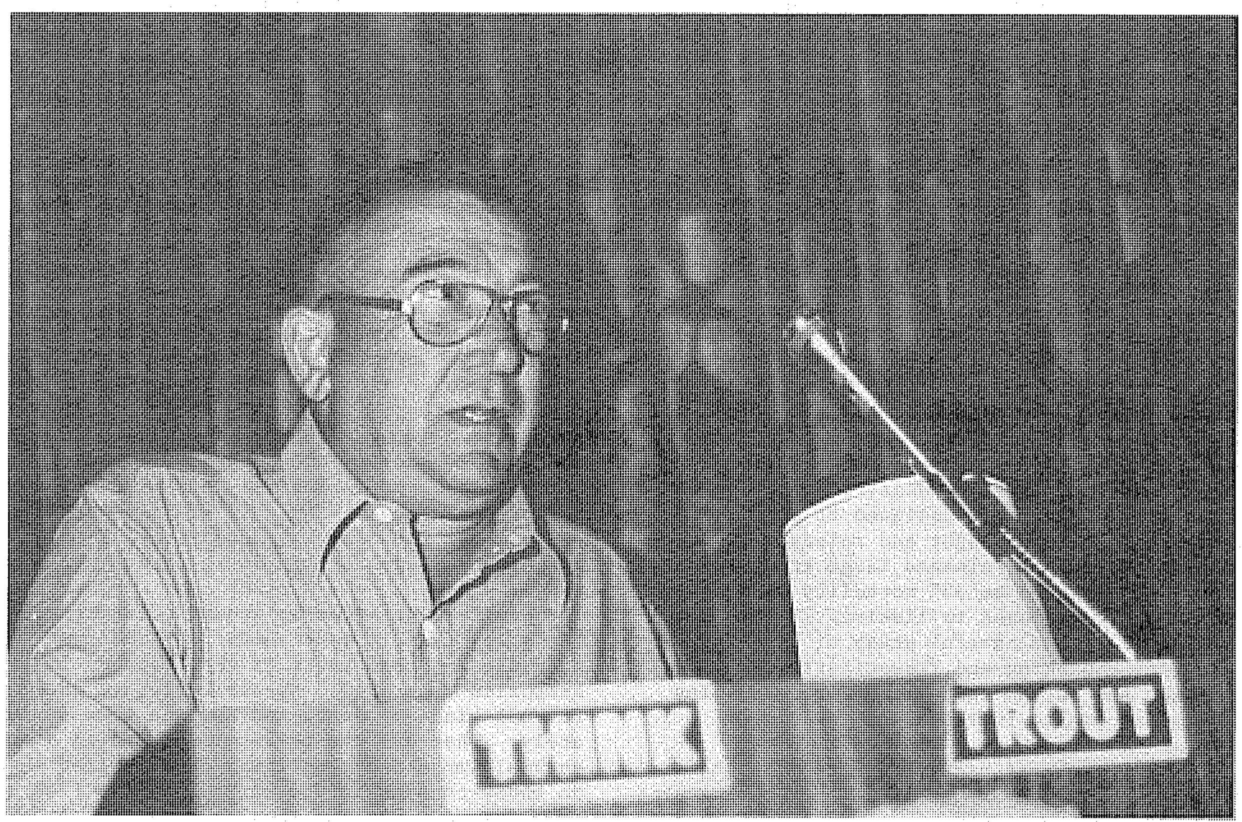
The Madison River studies, reported by Marcoux, were elegantly designed to answer some big questions about caught and released trout. Summer mortality of released large trout (III +) was 47% as compared to 30% mortality in a comparable section closed to fishing. There is room here for some careful study of effective methods of unhooking and resuscitating played-out fish, and beyond that a need for educating the angling public in these skills.

Now let me come back to my favorite theme, namely, that our major problems in perpetuating trout concern treatments of the watershed, not treatments of the trout. At the risk of sounding like a broken record, I feel obliged to repeat the admonition I delivered to this symposium five years ago. Our research is still lopsided in favor of fish, fishing, and fish water. I did note in the papers, and particularly in discussion, repeated reference to the fundamental relationship between trout fisheries and watershed management. The problem is recognized, but much more relevant research is needed. If we had at our disposal accurate, quantitative data on how grazing, logging, etc., affect trout, we could more effectively influence land-use decisions made by others.

Livestock grazing was repeatedly mentioned as being a serious issue in stream preservation. Bill Platts did his usual masterful job of depicting the nature of the problem and the way in which livestock may abuse riparian vegetation and destroy streambank stability. Raleigh and Duff elucidated the possibilities of restoring some habitat values in streams by placing artificial structures, but only if grazing is first controlled. Eiserman summarized the legal difficulties of trying to legislate stream protection--an approach always treated with great suspicion by the livestock and agricultural interests. Senator Wilson of California gave us an impromptu report, during a discussion period, on his Trout and Steelhead Conservation Planning Act which happily was passed by the Legislature and signed by the Governor in recent days. The August issue of "Streamkeepers Log" published by California Trout gives a good account of the initial opposition to this bill by the logging lobby, organized cattlemen, and State Chamber of Commerce, in fear that it might impede the complete freedom of land use by one or another of the land exploiters. These anti-interests were mollified when they were assured that the bill would deal only with trout and not with land use. But here of course is the basic issue. As I think Bob Behnke remarked yesterday, we are not talking about a fisheries problem, we are dealing with problems of land management. How are we to cope with issues that appear to be beyond our responsibility? We as biologists have only one option here, and that is to gather and analyze data on the actual relationships between land use activities in riparian zones and stream productivity. In my judgement, we are not yet pursuing the studies needed to prepare our legal briefs in the argument.

Instead of pointing accusing fingers at those who despoil watersheds, why don't we assemble the cold facts of what happens in a despoiled watershed? Specifically, we need several kinds of data, and we need them desperately. What are the physical changes in a stream channel imposed by poor grazing practice? How do these changes in the stream depress fish populations? How can these adverse effects be reversed by altering or locally eliminating grazing, perhaps in combination with stream improvement structures? The statement was made yesterday that the greatest opportunity to restore trout fishing in the West lies in learning how to reverse the effects of past overgrazing on the riparian strip. This idea I fully accept. But we need data and proven management techniques to attack this problem. May I urge all of you who administer fisheries programs to assign a high priority to the study of watershed relationships to trout populations. With good data we can be invincible in pressing for better conservation of those riparian strips that are so important to our interests in fisheries. Moreover, the protection of riparian vegetation from either grazing, logging, or other abuses will yield additional benefits beyond fish. Don Erman of my department in Berkeley has determined that a buffer strip 30 meters on each side of a stream, protected from logging, grazing, roadbuilding or other disturbance, will essentially assure the continued productivity of a stream. Dick Woodworth yesterday added the point that this strip would be critical habitat for many other species of birds and mammals. The opportunity awaits us. Let us direct our energy and resources to assembling the data (meaning the ammunition) to prove the point, that protection of the riparian strip is the key to trout management.

Then when we reassemble in another five years and Bob Behnke asks, "What the hell good came out of Wild Trout II?", we can have an answer for him.



Keynote Statement
Wild Trout II Symposium,
Yellowstone National Park,
Montana,
September 24-25, 1979

Nathaniel P. Reed

Welcome! Welcome to Yellowstone National Park. Welcome to the second Wild Trout Symposium. Let's pledge to make the hours we spend together productive, challenging and beneficial to our lifework and to the glorious, ancient sport which we share and cherish.

The giving of thanks is usually saved for the final moments of successful meetings, but in this case, confident of the eventual outcome, I want to thank Frank Richardson, John Peters, Pete Van Gytenbeek, Gardner Grant and Michael Owen for their persistent efforts in bringing together this assemblage of distinguished expertise. The familiar, distinguished face of my former colleague and mentor Willis King will again be in evidence. I can't imagine holding a wild trout symposium without the presence of this very wise man. Thank you, Willis, for again accepting the challenge of editing the Symposium papers.

Having worked closely with Starker Leopold I am confident that the organizers of the Symposium selected the absolutely best moderator and summarizers in the nation.

Special thanks go to Assistant Secretary Bob Herbst. I remember all the pitfalls and all the quiet back-scene work that must go on to pull off a Symposium such as this one. Let me assure you that without Bob's determined involvement we would not be here.

Special thanks also go to Superintendent John Townsley and his exceptional staff for overseeing our accommodations and insuring us a spell of Yellowstone's fall weather; complete with honking geese, the whistling wings of thousands of waterfowl, the bugling of rutting elk and the majestic change of color which precedes the timeless advent of another winter.

Thank God that in 1870, wise men had the courage and foresight to place this unique area in special custody dedicated to a combination of preservation and wise use.

As I age I become more aware that I own nothing, but I share the legacies of the past as well as the decisions which will shape the future.

I wonder if America's problems in 1870 were any smaller or less intense than they seem at present. I doubt it. I think the wise men who supported the withdrawal of Yellowstone had more courage than their contemporaries who seem incapable of concluding the last great chance to do something right for Alaska.

In a world that is increasingly filled with danger, with deadly choices and deeply troubled by the specter of a narrowing horizon we have a rare opportunity to discuss one of mankind's most civilized pursuits. It was the Romans who first cast for Salmo salar and gave us our foundation of law; the British developed fishing into an art form and gave us our language.

Let us put aside the worries of the day, the clouds of doubt, the seeds of trouble and spend the next two days immersed in the critical decision making that can improve the quality of our sport. Actually, I don't really believe that fishing is a sport for the majority of the people in this room. No, not a sport. I think the genes of ancient man flow freely in this room and that fishing is far more than a sport; it is a major part of our lives. I am not ashamed to be known as a passionate fisherman, I rejoice that I am so lucky!

In the November 1978 issue of the Pennsylvania Angler I came across a really provocative article entitled "A Message to Quality Anglers" written by Delano Graff, Chief, Division of Fisheries. His article should be given as a paper at this meeting.

He concludes with a quote from T. G. Northcote, an eminent Canadian scientist, which bears repeating:

> The practice of sport fishing is steeped in antiquated and delightfully inefficient methods of capturing fish which have undergone

little radical change for centuries. Nor will these methods, like the properly conservative attitude of their proponents, probably change in the near future. If this be the case, and we continue to manage fisheries or the majority of our inland waters solely or largely for sports fishing, then it may well be a serious mistake to aim at anything near maximum sustained yields. To do so would require an intensity of effort so high that the recreational value of the fish would become reduced if not negligible. Sport fishing is, after all, a sport and thereby should be an aesthetic experience pursued for the sustained pleasure of man, not the maximum sustained yield of fish flesh.

As we discuss the problems of wild trout, salmon and steelhead management, we should momentarily look back and rejoice how far the concept of "quality" sport fishing has come. Obviously, quality means many differing things to the various beholders, but to me, quality fishing whether it be for wild trout or a mixture of wild and released fish means good management. Good management of the land, the watershed and the fish stock takes competency, knowledge, great courage and the ability to attract public support.

I rejoice in the efforts in the vast majority of the state agencies to squarely face the question of what is "quality" and in the efforts to dedicate streams and portions of rivers by special regulations to give the angler opportunities to choose where he wants to spend his precious time.

I am genuinely impressed with the members of most of the state fisheries staffs who are willing to try new techniques and new regulations to find a better mix for the discriminating sportsman. Some young biologists have taken great risks. I honor them.

The compelling reason to wage what will be a tough political fight to broaden the Dingell-Johnson Act is to insure proper funding of our states' fisheries programs. I think we can succeed if we tell the remarkable story of what the fisheries' managers can and are accomplishing.

Our sport faces vast problems.

Acid rain is taking a terrible toll on much of the eastern wild trout fishery. Thousands of acres of once-productive water are now sterile. All the marvelous Adirondack lakes that I fished as a boy are void of trout.

The Atlantic salmon situation has degenerated to a perilously low level. Mismanagement, poaching, disputed Indian treaty fishing rights, radical and insidious habitat change combined with two of man's baser instincts -- avarice and greed -- seriously threaten the future of Salmo salar.

PCB's and other apparently ubiquitous chemicals seriously degrade the Great Lakes fishery after 20 years of intensive, expensive and successful Canadian-U.S. efforts to control the deadly sea lamprey.

New energy production initiatives threaten valuable habitat throughout the Rocky Mountain region. Habitat is continually sacrificed for more irrigation, more timbering, more grazing, more, more, more. The Pacific coast scene is troubled by a series of complex, vexing conflicts which threaten the resource and the stability of relationships between Indian and non-Indian.

The pie can only be divided so many ways. Does habitat protection always become the lowest priority? Listening to some of the political candidates one would think that Americans want to turn their backs on the genuine progress that we as a people and we as a nation have made in the past twenty years.

Are we really so frightened that we are willing to say "it was all a mistake, the environment be damned, man and man's needs have every priority", and that "no impediments should be placed in the way of 'progress'"?

I hope the American people know and understand that it is not nice to fool with Mother Nature. Those who want "hands off", and those who live by promising more have a very limited view of the nervous future of small, whirling, over-populated earth. If we turn power over to thoughtless men, we may temporarily raise our GNP and perhaps even ease the energy strain but surely we will leave a grim legacy for which our grandchildren will loathe us.

Rex Ressler, formerly a distinguished senior officer in the U.S. Forest Service and presently Executive Vice President of the American Forestry Association, recently wrote:

> One of the most sobering aspects of our time is the dawning recognition of just how finite and fragile our world truly is. International competition for dwindling petroleum supplies,

long gasoline lines, double-digit inflation, rising unemployment, and a continuing decline in the relative productivity of our free-enterprise system are but a few of the compelling realities that bombard our consciousness. And every solution proposed for these and many other issues raises the specter, or the reality, of environmental impacts.

Our political system, which has been characterized as the worst one in the world except for all the others, is largely influenced by the strident and often narrow perspective of various interest groups trying to mold the minds and actions of the Administration, the Congress, and the general public. Though this may not be the most efficient system for reaching decisions affecting the lives of all citizens, it is the way our system operates. The checks and balances within our system of constitutional democracy work, as has been proven innumerable times, but they also produce wide swings in the pendulum of public attitude. And therein lies part of the problem.

The latest assessment of the nation's forest and rangelands and the projections of supply and demand for natural resources and for the use of land and water clearly show that we are on a collision course with scarcity. That assessment also suggests that with moderate but timely course corrections, we could minimize many of the impacts of scarcity that will otherwise be with us in the early part of the 21st Century. The decisions we make, or fail to make, in the next few years will define the nature and magnitude of those impacts. The health of our environment and national economy, our social well-being, and perhaps some of our most cherished freedoms may indeed be affected in the future by our actions today.

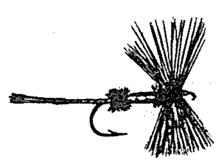
There are course corrections we can make, not the least of which is to constrain our appetites for material goods. We can substantially extend available supplies by making much more efficient use of raw materials. We can recycle raw materials. We can use more renewable resources in place of nonrenewable resources. And we can significantly improve the efficiency of producing raw materials in ways that are environmentally acceptable -- if we set our minds to the task. We face the unsettling dilemma of knowing that we must protect the quality of the environment and at the same time must develop the natural resources on which our free-enterprise system depends. The prospect of renewable-resource scarcity can be seen as clearly today as we could see a decade ago -- and did not believe -- the growing scarcity of petroleum supplies. Possibly the greatest hazard we face is the backlash that is likely to occur in the future if the public should become persuaded that rising costs occasioned by resource scarcity are too high a price to pay for a healthy environment. That swing of the pendulum must be avoided.

It seems to me that one of the most important responsibilities of the leadership represented in this room is to guarantee that Americans face their future with their brains, not their guts.

I did not come here to give a political speech, nor a chilling view of the clouded future.

No, I came here to hear and discuss with a magnificent group of devoted fishermen, biologists and fisheries managers the opportunities and the challenges which make up our collective future as we discuss the civilized subject of wild trout management.

Starker, take it away....



RESEARCH PANEL

Discussion Leader

Robert Behnke
Associate Professor
Department of Fishery and Wildlife Biology
Colorado State University
Fort Collins, Colorado

Basically I am somewhat of a skeptic in relation to a symposium really effecting meaningful changes by influencing agencies to make better use of wild trout resources. Yet I am optimistic that this symposium will be a significant step towards a more realistic assessment of the potential of our wild trout resource and for the implementation of some of the things we have discussed here.

There is a wealth of genetic potential contained in our wild trout resource that awaits being put to use by innovative and creative fishery managers and administrators. Wild trout management and innovative programs will invariably suffer when an agency becomes overburdened by the production of domesticated trout for fishery programs.

The following actions will lead to increased and more diversified angling opportunities in the future.

1. Use of genetic resources of wild trout.

   The typical technique in treating a problem body of water (for example, a lake with abundant nongame fishes) is to poison it and restock with domesticated hatchery trout that are virtually helpless in the face of competition and predation. Many races of trout native to the West have a long evolutionary heritage of coexisting with and preying on these nongame fishes under harsh environmental conditions. Wouldn't it be at least worth some time and effort to experiment with these preadapted races and attempt to turn a "rough" fish problem into a forage fish asset?

   In some of the desert regions of the West, the native "redband" trout (a distinctive form of interior rainbow trout) has evolved under a harsh and highly fluctuating climatic regime. I have caught these native "redband" trout on dry flies in 83° F water. Do the special genetic adaptations possessed by desert region "redband" trout suggest some possibilities for innovative fishery programs?

2. Special regulation fisheries.

   Special regulations whereby all or some of the trout caught are released to be recycled in the fishery must become a more widely used management tool if quality fisheries for wild trout are to be maintained under ever increasing fishing pressure. The problem is that despite many years of experience with various types of special regulations, there are not the comprehensive data needed to accurately predict where special regulations will work best for any particular situation. For too long agencies have more or less used the "dart board" approach in the selection of waters for special regulations.

   Such information as angling pressure (in angler hours per unit area), size, age structure, biomass and production rates (how much surplus production does a population produce each year) are needed to make sound decisions. How much angling pressure is required to catch 50% of a year-class in a fishery? Under most circumstances, unless we are dealing with a particularly long-lived trout population with low natural mortality rates, special regulations will not work a dramatic change to produce more older and larger trout if the annual angling kill is much less than 50% of the catchable size trout.

A fact that has been historically ignored is that there is a tremendous difference between trout species (and even between races within a single species) in their vulnerability to being caught by fishermen. Thus, angling pressure of 500 to 800 hrs/acre may not overexploit a brown trout population, whereas 20 hrs/acre or less can overexploit a population of cutthroat trout. Thus, cutthroat trout will produce strikingly better results than brown trout when subjected to special regulations. This simple fact endows the cutthroat trout with a very practical management asset. Hopefully more western states will recognize this asset possessed by their native cutthroat trout and the trend towards extinction of this rare and beautiful fish, caused by past management practices, can be reversed.

3. Environmental protection and improvement.

There are enormous opportunities to fight for better land use management to protect or restore our aquatic resources. In the 11 western states, about 50% of the land (and most of the public trout waters) is under Federal control (mainly Forest Service and Bureau of Land Management) and subject to multiple use management. Improved multiple use management on Federal lands could lead to an increase of millions of pounds of wild trout annually. Grazing by domestic livestock on public lands is a particularly acute problem in many areas in relation to the maintenance of a quality trout environment. Better management of grazing, recognizing the significance of trout streams, could restore or improve thousands of miles of streams to their natural carrying capacity.

Involvement in issues of land use decisions and multiple use management is more difficult and perhaps not as attractive as planting Vibert boxes or demanding catch-and-release programs, but as a long term investment in the future of trout fishing in America, the return will be much greater. Organizations such as Trout Unlimited, the Fly Fishermen Federation, and Cal Trout can be increasingly effective instruments for influencing better multiple use management on public lands if their personnel are knowledgeable and well versed on the subject matter and the facts.

The professional biologist should seek ways to cultivate the trust of angler groups. Requests for special regulation fisheries should be discussed on the basis of facts developed from intelligent assessment, and not dismissed or agreed to on vague generalities.

Most professional biologists take a dim view toward requests for stocking eggs in Vibert boxes to improve a trout fishery. They realize that in most trout streams a great surplus of natural reproduction occurs and the hatching of more trout only aggravates the problem of high (90-98%) natural mortality during the first year of life. Also eggs available to put in Vibert boxes almost always come from domesticated hatchery trout--the genetics of the trout cannot be changed by putting eggs in boxes. Yet there are opportunities to utilize such devices as Vibert boxes; for example, lakes without adequate spawning tributaries or when attempting to establish a new species. Look for such opportunities where the time and talents of sincere anglers can be utilized in cooperative efforts and avoid devisive rifts. We should all be working in the same direction--for better wild trout fishing.

CURRENT STATUS OF THE WHITLOCK-VIBERT

EGG INCUBATION BOX[1]

Roger A. Barnhart[2]

Abstract.--This paper gives background on the development of the Whitlock-Vibert (W-V) egg incubation box, a description of the W-V box and techniques used in employing the W-V box to bury salmonid eggs in gravel, a summarization of recent and current W-V box projects and a report on research underway to evaluate the W-V box as a means of reseeding salmonids streams. With good gravel conditions the W-V box method produces a high yield of fry, equal to or better than direct gravel plants. With poor gravel conditions the W-V box tends to collect fine sediment with egg suffocation and fry entrapment as possible sources of increased mortality.

INTRODUCTION

Since at least the turn of the century fish culturists, fishery biologists and fish enthusiasts have attempted in various ways to plant the artificially spawned eggs of fish, generally trout or salmon, into their natural environment. A major reason for using this method to establish fish in un- or underutilized habitats is the comparative ease of transporting eggs into remote roadless areas. This was often the situation in the lower 48 states in earlier days and the method is still used to some extent in isolated areas in Alaska and British Columbia. Because of the fragility of trout and salmon eggs many people intuitively devised systems to protect the eggs from physical damage while incubating in the stream gravels. One of the earliest reported devices was the Harrison Box developed in British Columbia in the 1920's (Harrison 1923). Stockley 1954 reported on a method he developed to seed remote streams in Alaska with red salmon eggs.

As hatcheries were constructed, fish-culture techniques refined, and better modes of transportation developed, many fishery organizations began using fry or fingerling plants to seed their waters, both remote and accessible. Many isolated lakes are still stocked today with trout fingerlings by airplane. However, it was discovered that the ability of wild salmonids to survive the rigors of stream life exceeded that of their domestic counterparts. Schuck 1948 discussed the problem of low survival of hatchery produced fingerlings and catchable-sized trout after stocking in streams. For this reason many states currently have a policy of not stocking trout and salmon fingerlings in streams.

And so another reason for planting trout and salmon eggs into their natural environment: fish would be produced which have high survival rates and yield high quality fish for the creel. Experiments demonstrated that fry produced in hatchery trays and troughs were smaller than their brothers and sisters produced in natural gravels (Babcock 1911; Mead and Woodall 1968). For these reasons Dr. Richard Vibert, an employee of the French Ministry of Fisheries, designed and patented the Vibert Box in 1950. Although he agreed with the principles of the "Harrison System" he felt the Harrison Box was too cumbersome. The Vibert Box, a small plastic container with lid and perforations on all sides holding up to about a thousand trout eggs, produced good results in France and later it was mass produced and sold throughout Europe and

[1]Paper presented at the Wild Trout II Symposium, Yellowstone National Park, September 24-25, 1979.

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eventually introduced into the United States about 1967. Trout Unlimited and the Federation of Fly Fishermen soon adopted the Vibert Box program and began to promote its use.

DESCRIPTION AND USE OF THE WHITLOCK-VIBERT BOX

In the mid-1970's the Federation of Fly Fishermen (FFF), working with conservationist, author, artist, professional fly fisherman Dave Whitlock began to test the Vibert Box. Whitlock eventually designed the Whitlock-Vibert Box to meet problems encountered when eggs had to be incubated in less than ideal substrate conditions. The Whitlock-Vibert Box, dubbed the "WVB", has two chambers as opposed to the single compartmented Vibert Box--an upper incubator chamber and a nursery chamber below. The principle of the WVB is that the incubator protects and hatches the eggs and the resulting sac fry pass through slots in the floor into the nursery chamber where they are protected until emergence. The polypropylene WVB has been mass produced and is molded flat. It is therefore easily shipped and folds into an assembled box 145x90x60 mm which can be cleaned and reused. The incubator chamber can be charged with up to 500 eyed eggs which FFF recommends although green eggs can also be used.

FFF has published a 47 page handbook authored by Whitlock which instructs in detail the use of the WVB. The handbook recommends careful stream site selection and proper site preparation before planting the charged boxes. The WVB is placed in a level horizontal position with a small cement anchor underneath, a locator line with wire anchor attached to the side of the box and buried in gravel to a 6-10 inch depth. With the aid of the locator anchor and a suggested streamside tag most WVB's can be recovered after fry emergence which allows the calculation of percentage hatch since the dead eggs are normally retained in the incubator chamber. FFF now sponsors the "WVB System" and has developed along with the handbook an audio/slide program. FFF has also trained WVB consultants to assist Federation clubs or other interested groups or agencies in the use of the WVB.

CURRENT WVB PROJECTS

According to the FFF 1978-79 annual report the WVB handbook is selling at the rate of about 500 annually and the WVB boxes at the rate of 2500 per year. Over 50 projects involving sportsman groups or individuals in at least 15 states have used the WVB system in the past three years. In addition the system has been used in Canada, Argentina, Australia, England, Germany, Holland, Mexico, New Zealand, South Africa, and Sweden. A 1976 FFF report summarized the Vibert Box and WVB projects since 1970: seventy-three groups or individuals in 26 states, 4 Canadian provinces and West Germany used over 3600 egg incubation boxes.[3] Species of fish utilized by the WVB system have been brown trout, cutthroat trout, brook trout, rainbow trout, kamloops rainbow, golden trout, and summer steelhead. FFF has developed a questionnaire whereby those using the WVB system can report back information concerning the specifics of their particular project. The form includes such information as fish species; number, cost and source of eggs; number of boxes planted and recovered; stream characteristics; unique techniques used to plant boxes, number of people and man hours required; and average and range of percentage hatch. FFF claims better than an 86 percent overall average hatch from the various WVB projects. Those groups experiencing low percentage egg hatch generally had problems with silting from floods, dewatering, freezing of eggs or a combination of these conditions. Surprisingly most groups experiencing such failures try again the following season; trying to select better planting sites or otherwise overcome their problems.

Issue III of the 1979 Flyfisher magazine reports on two fairly typical WVB projects. Twenty-one people, mostly members of Fresno, California's Fly Fishermen for Conservation (FFFC) planted 21,000 eyed brown trout eggs in WVB boxes on a Saturday in December, 1978 in a 5-mile fly fishing only section of the lower Kings River. The eggs were obtained from the California Department of Fish and Game. Prior to planting the group had hauled in several truck loads of incubation gravel to the selected planting sites. This project was unique in that it was instigated by 14-year old Bruce Donly, a junior member of FFFC, as partial fulfillment for an Eagle Scout Badge. Due to dewatering from a dam upstream two boxes were exposed and the eggs lost. However five weeks after planting, the remaining boxes were recovered and a 93 percent hatch was reported. Club members are eagerly awaiting the recovery of the brown trout population in that section of Kings River

The other WVB project reported in Flyfisher involved the Fourth Corner Fly Fishers of Bellingham, Washington and the Northwest Anglers of Seattle in cooperation with the Washington Department of Game. Club members

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[3] Cunningham, R.M. 1976. Vibert box and Whitlock-Vibert box information. Unpublished manuscript, FFF. El Segundo, CA 12 p.

planted Washougal summer steelhead eggs in the South Fork of the Nooksack River: 13,400 in 1975; 20,000 in 1976; 28,800 in 1977; and 32,500 in 1978. They plan to continue planting the Nooksack until self-sustaining runs are established or until it becomes evident that the program is not producing significant results. The first adult summer steelhead were expected back this summer. Egg to swim-up fry exceeded 90 percent in the group's last four plants. Electro-fishing by Department of Game biologists has shown that age 0 and age I+ steelhead juveniles have increased five-fold in the test section of the Nooksack since the project's inception. Some interesting quotes from the article: "By working with the fish and the stream in an intimate fashion, we became sensitized to the fragility of stream life networks and the enormous improbability that nature (and man) places in the path of the steelhead's survival struggle." . . . "By involvement, we learned something of the basic principles and complexities of fish management and stream ecology." . . . "Terms such as *carrying capacity, yield ratios* and *interspecific competition* became working parts of our vocabularies. In brief we became lay biologists. Armed with knowledge gained by program participation, we were more intelligently able to support the aims of our Game Department, as we did - - -." Members considered newly emerged fry they observed in the stream as their "babies."

RESEARCH INVOLVING THE WVB SYSTEM

The WVB system has not received complete acceptance, particularly among resource management agencies. Realizing that data evaluating WVB in a more precise manner were lacking, FFF has provided WVB boxes to scientists and in some cases partially funded research efforts to provide "acceptable" information on the system. A session of the 1979 annual conclave of FFF held in Colorado during August provided a report of current research efforts.

Dr. Thomas Harshbarger, Southeast Forest Experiment Station, U.S.F.S., at Asheville, North Carolina used the WVB, the Vibert box, and direct gravel introductions (Stockley method) to plant approximately one million brown trout eggs in South Mills River, North Carolina in the fall, 1976. Seven planting sites were used with 3-5 replicates at each location. Fry traps were used to estimate the number of fry leaving the gravel. Samples were excavated every two weeks to determine mortality. All eggs were subjected to two rigorous environmental conditions: 1. extremely cold temperatures resulting in freezing of the stream, and 2. heavy stream flows accompanied by movement of fine stream bed materials. Egg and sac fry mortalities were 100% in Vibert boxes, 85% in WVB boxes, and about 80% in gravel plants largely due to freezing and/or sedimentation. Sediment settled quickly over eggs in the one-compartment Vibert boxes whereas eggs in the incubator chamber of the WVB did not accumulate sediment until the nursery chamber below became filled. Observations made during the anchor ice period indicated that eggs in boxes containing sediment were more likely to freeze than those in unsedimented boxes. Gravel planting sites were generally not as badly sedimented which Dr. Harshbarger felt was due to less restriction of sediment movement through the site.

In the fall, 1977 four smaller tributary streams were planted with brown trout eggs. At each location five WVB boxes were compared with five direct gravel plants. Mark VI oxygen standpipes and fry traps were installed at each location. After emergence, gravel cores were extracted around WVB and direct gravel planting locations and sediment composition compared with that of nearby undisturbed sites. Direct gravel planting sites had resedimented to approximately the sediment level of undisturbed sites but WVB sites contained almost 3½ times more fine sediment than undisturbed sites. Undisturbed sites contained approximately 15-19 percent of sediment 0.8-4.0 mm size, direct gravel plant sites slightly less, and WVB sites contained about 30-32% sediment of that size. About 16 percent of the eggs in WVB boxes hatched compared to 31 percent in direct gravel plants. Production of swim-up fry from eggs planted directly into the gravel was 3-5 times greater than that from WVB plants. Harshbarger found that entrapment of emerging fry was a problem in both methods of egg planting but it was much greater in WVB boxes. An additional finding of interest was that two species of small North Carolina stream salamanders, the Blue Ridge two-line *(Eurycea bislineata)* and the northern dusky *(Fuscus desmognatus)*, can get into the WVB box and will prey extensively on the eggs or fry in the box. Harshbarger suggested a possible re-design of the WVB to reduce the sedimentation problem.

The Idaho Cooperative Fishery Research Unit (Dr. Robert White and Dudley Reiser) used WVB boxes as a research tool to plant eggs under a variety of physical and hydraulic conditions, to monitor egg survival, and to secure a representative sample of fry. Green and eyed steelhead eggs and green chinook salmon eggs were introduced into experimental stream channels. In one experiment eggs were subjected to a variety of sediment levels ranging from 0-50%, using two size classes of sediment, "coarse to medium" and "fine." In coarse sediment with eyed eggs there was little difference in egg survival at all sediment levels. Even in 50 percent coarse sediment, survival was quite high. With green eggs there was an inverse relationship between sediment level and egg survival. With fine sediment this same relationship occurred whether the eggs used were eyed or green and at 50% fine sediment 100% mortalities were experienced. Sediment-produced fry exhibited an inverse relationship between body length and sediment level. In another experiment 15 planting sites were selected in a small Idaho stream and WVB boxes used to plant chinook salmon eggs. At all sites, there was high survival to the hatching stage, ranging from 88-100 percent, and averaging 98 percent survival. Fry survival ranged from 0-100 percent and averaged 73 percent. Again, many WVB boxes had accumulated fine sediment in the chambers and fry entrapment was attributed to part of the fry mortality. The Idaho experiments are still in progress at this time.

The California Cooperative Fishery Research Unit began research in 1978 to evaluate the performance of the WVB system of egg incubation (Dr. Roger Barnhart and Gary Peterson). Egg planting experiments were conducted in both natural and artificial controlled stream environments.

Field experiments with steelhead eggs showed that WVB incubation produced superior hatching and emergent success compared to gravel-planted embryos. Starting with green eggs, in WVB boxes 96 percent survived to the eyed stage, 79 percent hatched and 46 percent emerged. Only about 16 percent of the gravel planted embryos survived to emergence. Eyed egg plants resulted in greater emergent fry production than green egg planting. Field trials with spring chinook salmon eggs demonstrated that the 3.3 mm width of the fry exit slots in WVB boxes may impede emigration of chinook fry hatched from large eggs (greater than 6.3 mm diameter). Accumulation of a considerable amount of fine sediment within WVB chambers during egg incubation further indicated that consideration of slight modifications in box design is warranted.

Artificial stream studies by the California Unit focused on assessing the effects of three different gravel compositions on steelhead survival to emergence and fry "quality. Under controlled incubation conditions, the WVB method consistently produced more fry from hatching to emergence than direct-gravel planting of eyed eggs. Differences ranged from 3.2-6.0 percent with a mean of 4.3 percent. In addition, eyed egg planting by the WVB system nearly completely eliminated initial embryo mortality associated with planting, while eyed eggs planted directly in gravel, despite careful handling experienced planting mortalities of from 2.6 percent to 37.8 percent (mean 17.6%).

Timing of fry emergence in "coarse" gravel was identical between groups of embryos incubated in black and white WVB boxes and in gravel. In addition, gravel-hatched embryos had equivalent patterns of emergence timing in the three gravel compositions tested. This was also reported by Phillips et al. 1975, who found no difference in timing of steelhead fry emergence from eight gravel compositions ranging from 0-70 percent 1-3 mm sand. However, increasing levels of 1-3 mm sand resulted in progressively and significantly later fry emergence from WVB boxes (0.5 days later in 20 percent sand and 1.75 days later in 40 percent sand). Associated with these delays were significant reductions in weight and relative yolk content at emergence for WVB hatched fry. It appeared that moderate to high levels of intragravel fines exerted a confining effect upon alevin egress from WVB boxes. Late-emerging fry were somewhat emaciated and exhibited suboptimal fitness for survival in the wild.

CONCLUSIONS

Results obtained to-date from various conservation projects and research efforts on the WVB system indicate that with "good" gravel conditions the WVB method produced a high yield of fry, equal to or better than direct gravel plants. The WVB also eliminates a wasteful initial mortality at planting due to physical crushing by gravel and protects eggs from shifting gravel, trampling by fishermen, livestock etc. during incubation.

Some problems with the WVB system have been revealed: In gravel with higher percentages of fine material the boxes tend to collect sediment, first in the lower chamber and eventually in the upper one. This may be due to a flaw in the design since holes in the bottom of WVB are slightly smaller than those on top. The associated problem of fry entrapment in boxes planted in gravel containing a high percentage fine material needs to be addressed. Perhaps a change in box design will help to alleviate this problem. Apparently the WVB does not prevent entry of predators such as small salamanders and carnivorous aquatic invertebrates--as proponents of the system have claimed. Naturally spawned eggs or eggs in direct gravel plants are also subject to the same predation and generally such predation is not considered a major source of mortality.

The WVB box holds a relatively small number of eggs and the WVB system is labor intensive which discourages its use for large-scale planting endeavors--a major criticism of the system by many fishery management agencies. FFF does not claim that the WVB system is meant to replace salmonid hatchery systems operating throughout the world but that the system has a place as a fishery management tool particularly in the production of "wild" salmonids. Further research is needed to test survival differences of fry produced from egg planting compared to hatchery produced fry, particularly through the first year of life. The WVB system does lend itself well to preserving or enhancing unique "genetically different" salmonid stocks--which a normal hatchery operation does not do. The WVB system has proved a useful tool for research work involving egg incubation, as demonstrated by the Idaho Cooperative Fishery Research Unit results. Last year, the California Department of Fish and Game used the WVB system to field test a stream in northern California to check on water and gravel quality for development as a major salmon spawning stream.

It is difficult to assess the value of groups of interested sportsmen becoming involved in personal and cooperative projects to enhance stream fisheries in their states. The WVB system educates these participants concerning the survival odds an adult trout or salmon faces, evokes a new appreciation in them for the fishery resource, and generates cooperation and support for fishery management agencies. FFF considers that the WVB program is still under development and plans to continue seeking ways to improve and utilize the system.

LITERATURE CITED

Babcock, J.P. 1911. Some experiments in the burial of salmon eggs--suggesting a new method of hatching salmon and trout. Trans. Am. Fish. Soc. 40(1910):393-395.

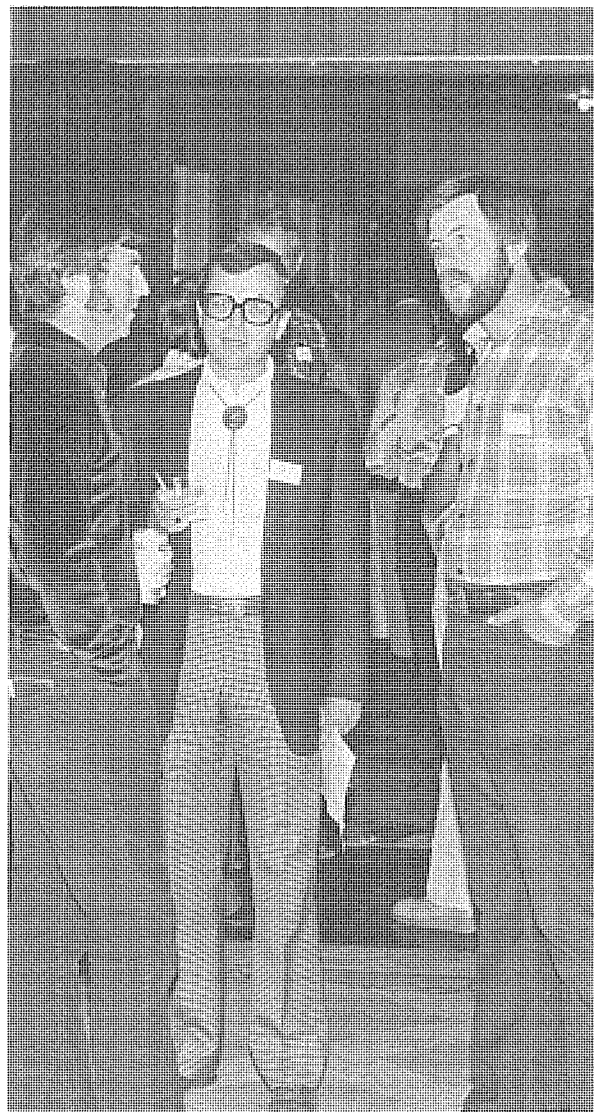
Harrison, C.W. 1923. Planting eyed salmon and trout eggs. Trans. Am. Fish. Soc. 53:191-200.

Mead, R.W. and W.Z. Woodall. 1968. Comparison of sockeye salmon fry produced by hatcheries, artificial channels and natural spawning areas. Int. Pac. Salmon Fish. Comm. Prog. Rpt. No. 20. 41 p.

Phillips, R.W., R.L. Lantz, E.W. Claire, and J.R. Moring. 1975. Some effects of gravel mixtures on emergence of coho salmon and steelhead trout fry. Trans. Am. Fish. Soc. 104(3):461-466

Schuck, H.A. 1948. Survival of hatchery trout in streams and possible methods of improving the quality of hatchery trout. Prog. Fish-Cult. 10:3-14.

Stockley, C. 1954. New method of artificially planting salmon eggs. Prog. Fish. Cult. 16(3):137-138.



GREAT LAKES LAKE TROUT: HAVE WE REALLY LOST WHAT WE ARE TRYING TO RESTORE?[1]

Joseph H. Kutkuhn[2]

Abstract.--Lake trout (Salvelinus namaycush), the reestablishment of which in the Great Lakes is the goal of a large scale intergovernmental effort, have been planted annually throughout the lakes for more than 20 years. Although able to survive reasonably well to early adulthood, these hatchery produced fish have yet to multiply in numbers sufficient to create self-renewing populations. Gaining support as a major reason for this failure is the notion that the stocked fish differ genetically from their ancestors; that the "domestic" trout of today are somehow reproductively inferior to the "wild" forms of yesteryear. But largely overlooked is the more likely possibility that premature and excessive withdrawal of the planted trout is retarding accretion of brood stocks to self-maintenance levels.

INTRODUCTION

Until rather recently, the lake trout (Salvelinus namaycush) flourished as the principal climax fish species throughout most of the Great Lakes. For more than a century after settlement of the Basin in the early 1800's, and probably for long before, it was sought as one of the more esteemed and readily accessible food fishes in the Lakes. Exceeded in cumulative landed volume by only the lake herring (Coregonus artedi), this species, on a completely self-sustaining basis, supported large and prosperous commercial fisheries well into the 20th Century. Its contribution as a food source to the social and economic development of the western Great Lakes Basin is a matter of detailed record.

But then, shortly after World War II, the unexpected happened. The valuable lake trout resource that many believed to be inexhaustible began to weaken, and the fisheries based upon it to wane. Blamed for the subsequent collapse, though still technically impossible to discriminate with certainty, were the effects of two factors: uncontrolled and increasingly heavy commercial fishing on the one hand, and severe depredations of the invading sea lamprey (Petromyzon marinus) on the other. Particularly affected by these disastrous circumstances were Lake Michigan's trout stocks, whose near-extinction by the mid-1950's spurred a basinwide, intergovernmental effort to suppress the sea lamprey and restore the lake trout.

Since 1958 in Lake Superior, 1965 in Lake Michigan, 1969 in Lake Huron, and 1971 in Lake Ontario, a major program entailing extensive lamprey control and massive trout stocking has been under way. Though already successful in many aspects, this large scale "experiment" has yet to realize its ultimate goal of reestablishing the lake trout as the paramount native species in the Great Lakes fish community. With the passage of time and in the face of ever-mounting program costs, the question of whether and when this goal will be attained is being asked with increasing frequency.

RESOURCE FEATURES

The lake trout, a typical coldwater stenotherm and largest of our endemic chars, is widely distributed across boreal North America. One may reasonably conjecture that in the Great

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Lakes, of all the large bodies of water this species inhabits naturally, its populations have attained the greatest proportions and economic value. Not surprisingly, therefore, it has been the object of considerable scientific interest. Over the past 50 years, and especially during the past two decades, much has been learned about its biology, ecology, and population dynamics.

For the purposes of this discussion, it is sufficient to note that in its wild state the Great Lakes lake trout is a relatively long-lived species with correspondingly moderate reproductive potential. Obviously a fragile resource, it can therefore be expected to be most stable in terms of its yield only when managed to ensure the continuous presence of as many age groups (or year classes) as possible, thereby damping the effects of year-to-year fluctuations in reproductive success. On the average, female lake trout mature and spawn for the first time at 6 to 7 years of age, males at 5 to 6 years; optimal fecundity is probably attained 4 to 5 years later. Average life span is in the range of 12 to 14 years; specimens as old as 16 years would not be considered uncommon, but those 20 years or more a rarity.

Growth may vary slightly with location as a reflection of ecological circumstances, but a female trout at first spawning, say 6 years old, averages in weight and length about 6 1/2 lb and 26 in., and produces 7,000 to 8,500 eggs. These inbred attributes of the species are major considerations, among numerous lesser ones, in the as-yet-unsuccessful effort to reestablish wild, breeding populations of lake trout in the Great Lakes.

IMPAIRMENT CAUSES

As noted previously, two factors: increasingly heavy fishing and severe lamprey predation, are held jointly responsible for the lake trout's demise. One may reasonably speculate from continuous records of the fishery that, despite indications of resource stability over many years, steadily mounting pressure on this valuable and easily extracted species gradually eroded both the (age) composition and size of its brood stock. With its productivity thus diminished and in a precarious state by the late 1940's, the resource was particularly vulnerable to the sea lamprey, which had become firmly established in the Great Lakes during the late 1930's and early 1940's. Degraded water quality and possible failure of food supplies have been generally discounted as significant contributing factors.

Debate has now continued for more than two decades over which of the major factors was the primary cause of lake trout decimation in Lake Superior, and virtual elimination from Lakes Michigan, Huron, and Ontario. Science has yet to provide a means for quantitatively distinguishing the relative effects of fishing and predation, and, in the specific case of yesteryear's wild lake trout stocks, probably never will. Moreover, it would seem to serve no useful purpose to further belabor the matter and merely heap more conjecture on that already offered in profusion. The fact remains, supported by more than ample logic, that of all forces or processes governing the productivity of a fish population, uncontrolled predation by man or by other organisms can be expected to have, ultimately, the greatest effect. When both predatory agents act together on an ecologically fragile resource like the Great Lakes lake trout, the impact can be dramatically quick and pervasive. The question of whether extraction by man or predation by lampreys was chiefly to blame for the trout resource's impairment is largely academic. Both had their lethal effect; the lake trout disappeared from a large portion of the Great Lakes. Something had to be done.

RESTORATION FACTORS

Response to the overwhelming trout-lamprey problem was rapid and well organized. By the mid-1950's, after only a few years' accumulating evidence of what indeed was happening, the governments of Canada and the United States had laid the groundwork for a broad-spectrum approach to a solution. In 1954, the two nations entered into the Convention on Great Lakes Fisheries, and, as provided for therein, established the Great Lakes Fishery Commission in 1956. As the major vehicle for coordinating intergovernmental management of the search for a solution, the Commission first undertook to fund development of a practical lamprey control technology. Subsequently it has underwritten comprehensive application of the methods developed, as well as continuing research on potentially more effective ones.

Evolving slowly as the focus of interagency cooperation in maintaining and protecting Great Lakes fish resources, the Commission, besides sponsoring sea lamprey research and control, has successfully promoted coordinated reestablishment of the lake trout as a major guiding policy of the management community at large. All Great Lakes states, the Province of Ontario, and both federal governments now subscribe officially to this policy. Most participate tangibly in pursuit of what many feel to be the attainable goal it represents. Implicit are several equally important considerations in restoration strategy: lamprey control, habitat improvement, forage availability, viable restocking material, and restricted use of the resource during its restoration.

Highly successful control of the sea lamprey in the Great Lakes is widely regarded as one of the more dramatic and notable achievements in the annals of fishery management. Accomplished by systematic and skillful application of a long-sought chemical selectively lethal to larval, preparasitic lampreys in their nursery stream habitat, it has so far been as instrumental as any factor in paving the way for the lake trout's restoration. But while suppression of this pest throughout the Great Lakes Basin remains necessary, so too does development of a control method demonstrably safer ecologically than the present one.

As lake trout habitat, the Great Lakes have changed markedly in some respects from their relatively pristine state of a half-century ago. Physically, with particular reference to their thermal attributes, they remain much the same: generally ideal for (coldwater) salmonines. Chemically, however, they have suffered considerable abuse. Well known are the discoveries of alarmingly high concentrations of mercury, DDT, Mirex, and PCB's in the flesh of certain fishes, including lake trout. Widely publicized, too, has been the accelerated enrichment (or eutrophication) of the lakes from uncontrollable, phosphorus-bearing agricultural runoff and the inadequately treated influx of domestic sewage. Although contamination by chlorinated hydrocarbons has impaired the use of some Great Lakes fishery products, its hypothesized effects on the productivity of the fish resources themselves has yet to be demonstrated. Such contaminants, though ameliorating as detection and abatement programs become more effective, nonetheless remain as potential impediments to lake trout restoration, especially in Lakes Michigan and Ontario.

Food supplies for the largely piscivorous lake trout abound throughout the Great Lakes, a possible exception being Lake Superior. They consist mainly of the non-native alewife (*Alosa pseudoharengus*) and smelt (*Osmerus mordax*), which in Lakes Michigan, Huron, and Ontario sustain not only the lake trout but also the growing (and competing) populations of other salmonids, particularly the introduced Pacific salmons (*Oncorhynchus* spp). In Lake Superior, the chief prey of the lake trout are the smelt, lake herring, and sculpin (*Cottus* spp.) whose densities there do not attain those observed lower in the Great Lakes system. Notwithstanding their always possible, unforeseen failure due to adverse environmental change and excessive cropping by other climax species, stocks of Great Lakes forage (or prey) fishes are generally believed (and expected) to be in more than ample supply to support a sizable, rehabilitated lake trout resource.

Given then the apparently favorable conditions for its potential reestablishment in the Great Lakes generally, we need but the lake trout itself, performing successfully upon reintroduction, to complete the picture. Obviously, fish hatcheries are the only practicable source of fish in the volume such large scale undertakings require. And as the species is very amenable to artificial culture en masse, many lake trout, indeed tens of millions of them, have been produced in government hatcheries for the Great Lakes. Since the mid-1950's (actually beginning in Lake Superior in 1947) hatchery produced trout have been regularly and widely planted, mostly as yearlings, throughout the Lakes. To date they have survived in goodly number--consistent with what would have been the reasonable projection of favorable conditions for maintaining rebuilt stocks in areas formerly harboring wild ones. But, as is stressed later, there is more to the restoration story than simply the survival of planted, artificially produced fish.

One might presuppose, too, that withdrawal of surviving, hatchery produced lake trout (for recreation or food) during the restoration process would be greatly, if not completely, restricted as an integral part of the reestablishment strategy. Although sanctions against the commercial take of lake trout have long existed in most areas of the Great Lakes, concessions have been widely made to sport fishermen who are everywhere allowed a nominal daily bag. Understandably, all such concessions can be expected to protract accumulation of spawning stocks, retard development of fully self-renewing populations, or even eliminate any likelihood that reintroduced trout, at least in some waters, will ever reattain self-sustainability.

PRODUCT PERFORMANCE

No one can deny that hatchery produced lake trout planted in the Great Lakes have prospered, and continue to prosper, far beyond what was believed possible when the trout-restoration effort began in earnest nearly 25 years ago. By any measure, their survival in absolute terms has been little short of remarkable. After a few abortive attempts with fall-planted fingerlings at the outset, great success is now achieved consistently with yearling (13- to 16-month-old) fish stocked in the spring.

As has been the rule from the beginning, all planted trout (with very few, usually inadvertent, exceptions) bear a distinctive mark. Almost invariably this consists of a single clipped fin or, less frequently today than formerly, a combination of two (rarely three) clipped fins. Though not completely discounted as a consideration in the continuing effort to maximize the numbers of planted trout reaching adulthood, the loss of a fin (or no more than two fins) is not believed to materially affect their survival. The significant decision to so mark all planted lake trout has immensely facilitated their subsequent tracking, and hence the follow-up evaluation of their performance. From the returns of marked trout observed in catches by anglers, by commercial and "contract" fishermen, as well as by survey biologists, we have learned much about trout movements; have been able to determine the relative efficacy of different rearing techniques, as reflected in the comparative survival of groups of planted trout so treated; and, most importantly, have been able for the most part to easily maintain the identity of each cohort or year class planted. Accordingly, much is now known about the growth and mortality of these "experimental" trout, but only during their existence in the Lakes as populations fully vulnerable to the various conventional fishing (and sampling) gears to which they are constantly exposed. Perhaps the most serious gap in our understanding of the trout stocks being rebuilt is the degree of and variation in their postplanting, prerecruitment mortality. Of a million yearling trout planted in a given area, we are unable to say with certainty how many can be expected to remain at recruitment (or to survive to parenthood) some 4 to 5 years later.

Notwithstanding this troublesome breach in our knowledge, the fact remains that enough surviving trout have accumulated to attract the more than passing interest of fishermen, both recreational and commercial. Especially in Lake Michigan and only somewhat less so in Lakes Superior and Huron, the reintroduced lake trout has virtually become the angler's "bread and butter" species. When the non-native salmons and trouts, perhaps the preferred targets, are not being taken, chances are more than good that at least one lake trout will "take the bait" and preclude an otherwise fishless trip. So accommodating has the lake trout proved to be that the local economies of numerous lakeside communities now depend heavily on the plantings that will sustain a healthy, attractive trout population in adjacent waters. In short--to the dismay of those dedicated to reestablishing the lake trout as quickly as possible, and to the delight of those enjoying access to the partly rebuilt supply--tens of thousands of lake trout have now been extracted by anglers, Indian-treaty fishermen, and others since restoration was instituted some 25 years ago.

But all is not well intrinsically with the planted lake trout. For though they generally survive at a rate and to a size making them ready and attractive objects of sport and commercial fishermen, they have yet to demonstrate the capacity to fully sustain themselves through natural, in-lake regeneration. Only recently in certain parts of Lake Superior have lake-produced, i.e., unmarked sub- and young-adult, trout been showing up with regularity and notable quantity in the catches of sport and survey fisheries. To the disappointment of many, none have so far been verified from Lake Michigan. Accruing stocks in Lakes Huron and Ontario have not been extant long enough to have produced comparably "fishable" progeny.

Unlike the trout resource in Lake Superior, that in Lake Michigan comprises, insofar as is known, completely artificial aggregations, the survivors of millions of lake trout planted each year since 1965. And chances are good that relatively few of the unmarked trout now being taken from Lake Superior are the progeny of hatchery produced parents accumulating from plants made annually since 1958; most are speculated to be the offspring of residual native stocks known to have survived (and which may be rebounding from) the onslaught of the sea lamprey. It should be noted, however, that very young fish, i.e., fry and fingerlings, have been observed each spring since 1975 in areas of southern Lake Superior where large groups of breeding trout, predominantly of hatchery origin, have been seen during the immediately preceding fall. Similar observations of spawning fish and subsequent young have now been made in eastern Lake Michigan (1979). All of these sightings confirm that mature trout, regardless of origin, will breed in the Great Lakes. Clearly, the problem now is with the limited extent of spawning as reflected by still insufficient brood stocks, and, in lesser degree, with what appears to be poor survival of offspring during early life stages.

As noted earlier, the female lake trout requires a minimum of 6 years to mature. The period from planting as year-old fish to maturation of their first progeny thus spans at least 11 years, to some an interminably long time for the potential fruits of trout restoration attempts to ripen. This salient but "inconvenient" feature of the lake trout's biology, given the species' innate resiliency otherwise, dictates the rate--the very slow rate--at which a brood stock may be expected to develop and, if all else goes well, for the lake trout to (re-) establish itself.

In Lake Superior the restoration process has now been under way for just short of 30 years, in Lake Michigan for less than 10 (as computed from the years in which the fish planted initially were first expected to spawn: 1957 and 1970, respectively). One may thus conjecture from the observations in Lake Superior, if indeed regeneration by hatchery produced stock is being witnessed there, that a wait of as much as several decades before reproduction first manifests itself significantly in terms of contributions to the breeding stock cannot be considered unreasonable. What must now be viewed with increasingly justifiable concern, however, is the delaying, if not the precluding, effect of ever more liberal trout withdrawals on the reestablishment of fully self-regenerating brood stocks. Inasmuch as tighter restrictions, even moratoriums, on fishing for Great Lakes lake trout are highly unlikely, attainment of the goal of reestablished trout populations would appear to be foredoomed. In the opinion of more than a few, we have clearly lost significant advantage in pursuit of this goal by not curtailing the rapid and premature removal of planted lake trout.

Even so, there are many who attribute the poor reproductive performance of accruing lake trout stocks, in as large measure, to factors other than the stocks' failure to have attained what might be termed "critical breeding mass." Some blame the practice of planting trout at convenient but undesirable sites, mostly at the water's edge, which results in the surviving fish returning there to spawn years later, over substrate and under environmental conditions offering little protection for incubating eggs and newly hatched fry. Others speculate that, because of many years' purposeful (artificial) selection of brood stock yielding progeny that perform best in hatcheries, heritable traits ensuring survival of early life stages in the wild have unwittingly been lost. Still others fault, specifically in the case of Lake Michigan, the adverse effects on eggs and young of toxic substances transferred to offspring via genesis of reproductive material in the parent. One is hard-pressed to reject any of these factors, singly or in combination, as not contributing in some degree to the planted trout's failure so far, particularly in Lake Michigan, to demonstrate the ability to complete its life cycle.

To eliminate the first of these considerations, i.e., traditional planting practice, as a possible cause of delayed regeneration by planted trout, Great Lakes fishery managers in the mid-1970's began stocking more and more fish, at greatly increased cost, on offshore reefs where lake trout were known to have spawned in pre-lamprey days. Up to 50% of all plants are now made offshore. But, since survivors of most of the earliest offshore plantings (1974) have not yet reached maturity and spawned, it is too early to tell if this change in procedure will lead to enhanced protection and survival of incubating eggs and hatching young.

Likewise, it seems highly problematical that the genetic constitution providing for the survival and adaptability of their wild, pre-lamprey ancestors can ever be incorporated into the lake trout now being produced in hatcheries and planted in the Great Lakes. There can be little doubt, for example, that the unique genotypes represented by the native Lake Michigan lake trout before its demise in the 1950's have been virtually lost forever. Remnants of original Lake Michigan strains are known to survive only in Green Lake, Wisconsin, from which brood material for progeny recently planted experimentally over Lake Michigan's Sheboygan Reef has been obtained. Since the genetic makeup of the all-but-lost strain(s) is not even imperfectly known, there is no straightforward way it can be reengineered into the strains' domestic successors. Only by chance, through costly trial and error selection of wild fish from different and promising sources, might the survival potential now deemed lacking in the progeny of present-day hatchery parents be reinstilled. Although systematic re-selection of brood material has some appeal, the great amount of time (up to 12 years each) required for completing the many necessary experiments would, alone, tend to discourage it. Certainly one disdains pessimism, but the probability is high that what we are trying to restore in the Great Lakes has, in a fundamental genetic sense, been essentially lost. It would thus appear that whatever survival potential remains in the domestic strain(s) of lake trout being planted can only be induced, in absolute or tangible terms, through their mass accretion and full protection as spawning stocks. In Lake Michigan, for example, the modal age of lake trout remains at about 6 years when logic dictates that it should now be closer to 11. Discouragingly few fish are advancing beyond 9 years. Accordingly, as many as possible of the planted fish must be protected. Not only ought their withdrawal by fishing be sharply restricted, but losses due directly to predation by the sea lamprey and indirectly to habitat impairment must be further curtailed through sustained control of this pest and protection of the environment.

MANAGEMENT IMPLICATIONS

The incomplete success of lake trout restoration attempts to date, together with increasing uncertainty about the likelihood of complete success in the future, poses some difficult questions for Great Lakes fishery managers: To dismiss restoration as a feasible goal and exploit the trout? Or to pursue it and protect the trout? One or the other? Experience so far suggests there may be little room for compromise.

Thriving on abundant forage and surviving well to fishable size, the planted trout, even as immature subadults, represent widely numerous, highly desirable, and readily accessible targets to would-be users, whatever the intended use. Thus if the regulatory agencies themselves did not promote lake trout fishing of any kind, they could not escape constant pressure by all elements of the user public--recreational and commercial--to allow it. Another factor complicating the logistics of lake trout protection is the trout's vulnerability as a non-target species to fishing gear aimed at other members of the fish community. Particularly troublesome to managers in some parts of the Great Lakes, for example, has been the incidental capture of lake trout in gillnets fished commercially for the lake whitefish (*Coregonus clupeaformis*). Salmon anglers, too, commonly encounter lake trout, which often occur together with the introduced Pacific salmons. Nonetheless, if fishing for lake trout were prohibited for purposes of accelerating the species' reestablishment, losses of trout taken incidentally in other fisheries could be significantly reduced by the use of non-injurious fishing gear and fish-handling procedures.

If, on the other hand, management is willing to indefinitely postpone or completely forego reestablishment of the lake trout as a long range goal, and simply maintain instead the kind of fishing that planted lake trout now provide, the managers are confronted with the prospect of having to sustain a predictably more costly as well as energy-intensive hatchery program. Indeed, one has to be concerned over our future ability, if not our willingness, to pay the rapidly mounting cost of producing lake trout artificially in the volume now demanded. Understandably, some managers remain convinced that in the long run only those lake trout fisheries supported by wild, fully reestablished stocks can be justified on economic grounds. Conventional management of such fisheries, entailing regular assessment of the fished, naturally reproducing stocks and projection (with enforcement) of their allowable catches, is becoming more and more appealing as the answer to insufficient hatchery budgets and uncertain energy supplies.

CONCLUSION

There now appear to be but two, essentially uncompromisable options for future management of the Great Lakes lake trout resource:

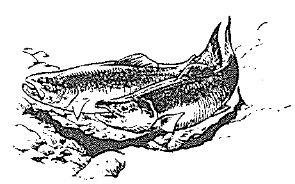
- o Promote put-grow-take fisheries like the costly ones now being enjoyed, thereby foreclosing the trout's widespread reestablishment and risking the loss of what is still viewed by many as a commendable intergovernmental initiative; or

- o Prohibit instead the withdrawal of lake trout while their populations are being rebuilt, thereby greatly enhancing the likelihood of the species' restoration to complete and cost-free self-sustainability.

To continue the lake trout restoration program as currently managed is, it now appears, to delude ourselves with the notion that full restoration of the species in the Great Lakes will ever be achieved. If reversion of the lake trout to fully protected status is deemed to be politically impractical, perhaps our most creditable recourse is to back off from restoration as a realistic goal attainable in the foreseeable future. If not, and all interests are able to agree that the trout's full protection can and must be accommodated, then, in my opinion, we have yet to "lose" the lake trout in terms of its potential as a productive, completely restored member of the Great Lakes fish community.

ACKNOWLEDGMENT

I am grateful to those of my professional colleagues who provided much of the rationale and some of the stimulus for this statement.



WILD BROWN TROUT STREAMS AND THEIR SPORT

FISHERIES IN CENTRAL WISCONSIN[1]

Ed L. Avery[2]

Abstract.--This study quantitatively characterizes wild brown trout populations and the sport fisheries they provide in four of central Wisconsin's most popular trout streams. Average spring density was 2,018/mile while the average standing stock was 96 lb/acre. Fishing pressure averaged 373 h/acre and anglers creeled 375 trout/mile. Exploitation of spring populations ranged from 15 to 24 percent and was responsible for skewing the populations toward smaller and younger fish.

INTRODUCTION

Wisconsin has 9,000 miles of trout streams and roughly 30 percent (2,700 miles) is designated as Class I trout water. The Class I designation is given to streams or segments of streams in which natural reproduction of trout is sufficient to fill the available habitat and hatchery stockings are not necessary to provide a sport fishery. Nearly all of Wisconsin's Class I waters contain native brook trout (Salvelinus fontinalis) and for this reason most research and management efforts have been directed toward the protection and enhancement of this species.

Brown trout (Salmo trutta) were introduced to Wisconsin in the late 1880's and are currently found in 29 percent (780 miles) of the state's Class I water. Quantitative information concerning brown trout and the sport fisheries they provide is noticeably scarce. A study was therefore initiated in the fall of 1975 to characterize wild brown trout populations and the sport fisheries they provide in four of Wisconsin's most popular streams in the central region of the state. The study concluded in the spring of 1978. This paper addresses the spring populations of brown trout, the sport fisheries provided by these trout populations, and the impact of the latter upon the resident populations.

THE STUDY STREAMS

Emmons Creek originates from Fountain Lake in southeastern Portage County and flows 6.0 miles before entering Waupaca County's 724-acre Chain O'Lakes (fig. 1). Radley Creek originates 3.0 miles south of Emmons Creek and flows 11.0 miles (includ. So. Br.) into the Crystal River near Rural, Wisconsin. Approximately 35 miles southwest of Radley Creek, the Mecan River originates from Mecan Springs in south-

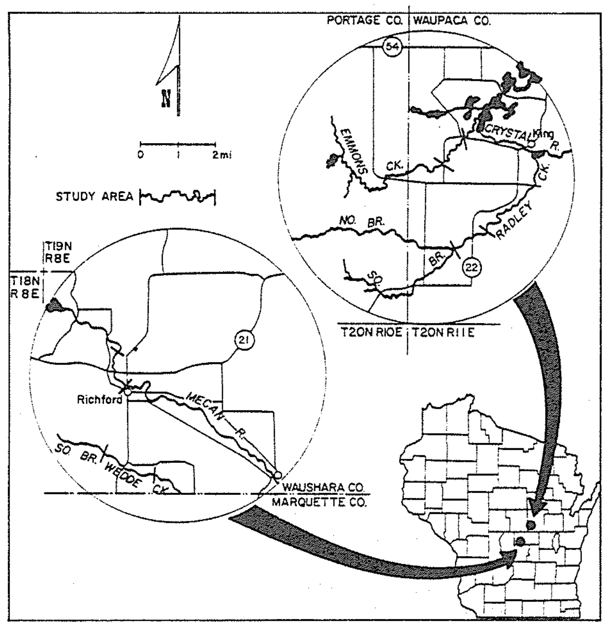


Figure 1.--Location of study sites.

[1]Paper presented at Wild Trout II Symposium, Mammoth, Wyoming, Sept. 24-25, 1979.
[2]Project Leader, Cold Water Research, Department Natural Resources, Madison, Wisconsin.

western Waushara County and flows 31 miles before emptying into the Fox River in Marquette County. The South Branch of Wedde Creek originates 4.0 miles south of the Mecan River and flows 4.9 miles before merging with the North Branch to form Wedde Creek. All of Emmons, Radley and So. Br. Wedde Creeks and the upper 6.6 miles of the Mecan River are Class I trout water. All four streams were once native brook trout streams but now support primarily brown trout. The Mecan River also contains a small but self-sustaining population of rainbow trout (Salmo gairdneri).

Study zones on the four streams ranged in length from 1.1 to 1.5 miles and were easily accessible to anglers through state-owned public fishing areas. With the exception of Emmons Creek, habitat improvement techniques have been implemented within each of the study zones. Stream substrates consist primarily of fine sand with gravel riffles occurring frequently in Emmons Creek and the Mecan River and occasionally in Radley and So. Br. Wedde Creeks. Aquatic vegetation was sparse to moderately abundant in the four streams and consisted primarily of watercress (Nasturtium officinale) and water buttercup (Ranunculus sp.). The food base for trout consists primarily of aquatic and terrestrial invertebrates. Mottled sculpin (Cottus bairdi) and brook stickleback (Eucalia inconstans) are present but not particularly abundant in any of the streams. A sparse crayfish population is also present in the Mecan River.

Emmons Creek and the Mecan River are the two largest streams with average widths of 19 and 22 ft, respectively, and average discharges near 22 cfs. Radley Creek is narrower and deeper than either Emmons Creek or the Mecan River but has a 20 percent smaller volume. The So. Br. Wedde Creek is the smallest of the four streams with an average discharge of 8.8 cfs and an average width of 12 ft. Pools more than 3.5 ft deep are uncommon in the streams and gradients are less than 15 ft/mile. Total alkalinities ($CaCO_3$) range from 131 to 186 ppm and conductivities range from 276 to 356 umhos/cm^2. The pH range is from 7.5 to 8.2.

Water temperatures from mid-June through mid-September range from the low 50's ^{o}F to the low 60's ^{o}F in Emmons and Radley Creeks with maximum temperatures rarely attaining 65^{o}F. Temperatures are similar in So. Br. Wedde Creek with the exception that maximum temperatures are commonly in the mid-60's. The Mecan River is the warmest of the four streams with temperatures reaching the mid-70's. Portions of all four streams remain ice free even during the most severe winters. Minimum winter temperatures generally hover between 33-34^{o}F in all but the Mecan River where they approach 32^{o}F.

METHODS

Petersen mark and recapture estimates of the trout populations were made each spring (late Apr.-early May) and fall (late Sept.-early Oct.) in the four streams. A small boat equipped with a 220-volt DC generator, one negative and three positive electrodes was used to capture fish. Lengths, weights and scale samples were collected from trout during each population inventory and all young-of-the-year trout captured in the fall were given a permanent mark (finclip) to aid in establishing known-age populations.

The sport fishery on each stream was determined in 1976 and 1977 through a partial creel census conducted throughout the respective fishing seasons. Wisconsin's trout season opens the first Saturday in May and extends through September. A bag limit of 5 trout/day in May and 10 trout/day from June through September was in effect during this study with a minimum legal size of 6.0 inches. Census effort on each stream was stratified. Opening weekend was considered as a separate stratum and a complete census was conducted each day. Thereafter, census effort was stratified each month so that 50 percent occurred on weekends and holidays and 50 percent occurred on week days. Census clerks worked one of two 8-h shifts (5:30 a.m. to 1:30 p.m. or 1:30 p.m. to 9:30 p.m.) per census day and averaged 40 h/wk. Census days and 8-h shifts were selected randomly. Instantaneous car counts were made at all access sites at 2-h intervals on each stream and angler interviews were conducted between counts to gather pertinent data.

TROUT POPULATION CHARACTERISTICS
SPRING 1976-1978

The average spring density of brown trout ranged from 1,268/mile in the Mecan River to 2,495/mile in Emmons Creek (table 1). The average spring density in the four streams as a whole during the 3-year period was 2,018 brown trout/mile. Average standing stock ranged from 59 lb/acre in the Mecan River to 114 lb/acre in Radley Creek with an overall average of 96 lb/acre[3].

Legal trout, i.e., fish $\gtrsim$ 6.0 in., comprised 37 percent of the average spring populations and 77 percent of the average spring biomass in the four streams (table 1). The number of legal fish averaged 733/mile but ranged from as high as 942/mile in Emmons Creek to as low as 512/mile in the Mecan River during the 3-year period.

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[3]An additional 8 lb/acre of rainbow trout was present in the Mecan River but will not be discussed in this paper.

Table 1.--Brown trout population characteristics in the spring (1976-78)

Stream	Average Density (no./mile)	Average Biomass (lb/acre)	Legal Trout (i.e., ≥6.0 in.) Average Density (no./mile)	Average Biomass (lb/acre)	Average Percent of Pop.	Average Percent of Biomass	Average Size (in.)
Emmons Ck.	2,495	100	942	79	39	79	8.0
Radley Ck.	2,322	114	824	91	35	80	8.4
So. Br. Wedde Ck.	1,989	112	655	78	29	68	7.8
Mecan R.	1,268	59	512	47	44	81	8.6
Grand Average	2,018	96	733	74	37	77	8.2

Few trout in the 5.5 to 6.5 in. range were present in the spring in any of the streams. This interval proved to be a natural break between age I and II fish. Most legal trout were in the 7, 8 and 9 in. groups. The average size of legal fish ranged from 7.8 in. in So. Br. Wedde Creek to 8.6 in. in the Mecan River, while the accumulative average in all four streams was 8.2 in. (table 1). Trout over 10 in. comprised an average of 5 percent of the spring populations while the number of fish over 12 in. accounted for only 1 percent (table 2). The latter was equivalent to between 15 and 20 trout/mile larger than 12 in. Obviously, brown trout larger than 12 in. in central Wisconsin's Class I trout streams are considered nice fish.

The age structure of the spring populations was dominated by age I and age II fish (table 3). Yearlings comprised two-thirds of the spring populations and averaged only 4.8 in. in length. A very small segment of the age I's were of legal size, i.e., 6.0 in. Age II and age III fish comprised 25 percent and 7 percent of the spring populations and averaged 7.9 in. and 10.1 in., respectively. Trout at least four years of age accounted for an average of only 1 percent of the spring populations and these fish averaged 12.3 in. Most legal trout available to the angler early in the fishing season were, therefore, two and three-year-old fish.

Table 2.--Average percent size frequency of brown trout populations in the spring (1976-78)

Stream	Size Categories (in.) ≤6.0	6-7	8-9	10-11	≥12
Emmons Ck.	61	22	13	4	<1
Radley Ck.	65	16	14	4	1
So. Br. Wedde Ck.	71	17	9	2	<1
Mecan R.	56	16	20	7	2
Grand Average	63	18	14	4	1

Table 3.--Average age structure (%) of brown trout populations in the spring (1976-78) (avg. length of age classes in parenthesis)

Stream	Age Class I	II	III	IV+
Emmons Ck.	61 (4.6)	29 (7.3)	9 (9.6)	2 (11.9)
Radley Ck.	66 (4.6)	25 (7.8)	8 (10.2)	1 (12.4)
So. Br. Wedde Ck.	77 (4.7)	18 (7.8)	5 (9.6)	<1 (11.9)
Mecan R.	63 (5.2)	28 (8.6)	7 (10.8)	2 (12.9)
Grand Average	67 (4.8)	25 (7.9)	7 (10.1)	1 (12.3)

Table 5.--Average percent harvest by size interval, 1976-77

Stream	Size Intervals (in.) 6-7	8-9	10-11	12+
Emmons Ck.	32	46	20	2
Radley Ck.	34	40	22	4
So. Br. Wedde Ck.	24	58	18	1
Mecan R.	23	42	24	10
Grand Average	28	46	21	4

WILD TROUT FISHERIES, 1976-1977

Fishing Pressure

Average estimated fishing pressure on the individual streams ranged from 331 h/acre on Radley Creek to 428 h/acre on So. Br. Wedde Creek (table 4). Pressure on all four streams during the two-year period averaged 373 h/acre. This was equivalent to between 2 and 3.5 angler trips per day per mile of stream.

The typical distributions of fishing pressure and harvest were evident during the two fishing seasons. An average of 39 percent of the fishing pressure and 26 percent of the harvest occurred during the first three weeks of the fishing season, i.e., during May. In general, fishing pressure declined gradually on each stream throughout the remainder of the fishing seasons.

Trout Harvest

Estimated angler harvest during the 1976-77 fishing seasons averaged 375 brown trout/mile in the four streams. Trout less than 10 in. in length made up 74 percent of the harvest with most fish being in the 8 or 9 in. groups (table 5). The average size of creeled trout in 1976 and 1977 ranged from 8.5 in. to 8.9 in. in Radley, Emmons and So. Br. Wedde Creeks but averaged 9.3 and 9.5 in., respectively, in the Mecan River. An average of only 4 percent of the harvest from the four streams consisted of fish larger than 12 in.

Table 4.--Average estimated fishing pressure, 1976-77

Stream	Hrs/A
Emmons Ck.	344
Radley Ck.	331
So. Br. Wedde Ck.	428
Mecan R.	388
Grand Average	373

Age structure of the monthly harvest varied during the two fishing seasons but was dominated by age II trout (fig. 2). Yearling harvest was of little importance early in the trout season but became progressively more important with time. This was a reflection of the low number of legal yearlings available when the fishing season opened in May and their subsequent recruitment into the legal segment due to growth. Monthly harvest of age III+ trout was, in general, the reciprocal of the yearling harvest. However, their numerical contribution to the angler's creel was much less.

Exploitation

Estimated angler exploitation of the spring populations of brown trout ranged from 15 percent to 24 percent in the four streams, with an average of 18 percent. Angler exploitation on the Mecan River and So. Br. Wedde Creek averaged 21 percent during the two years compared with an average of 15 percent on Radley and Emmons Creeks.

A more precise measure of the impact of fishing upon resident trout populations can be obtained by examining angler exploitation

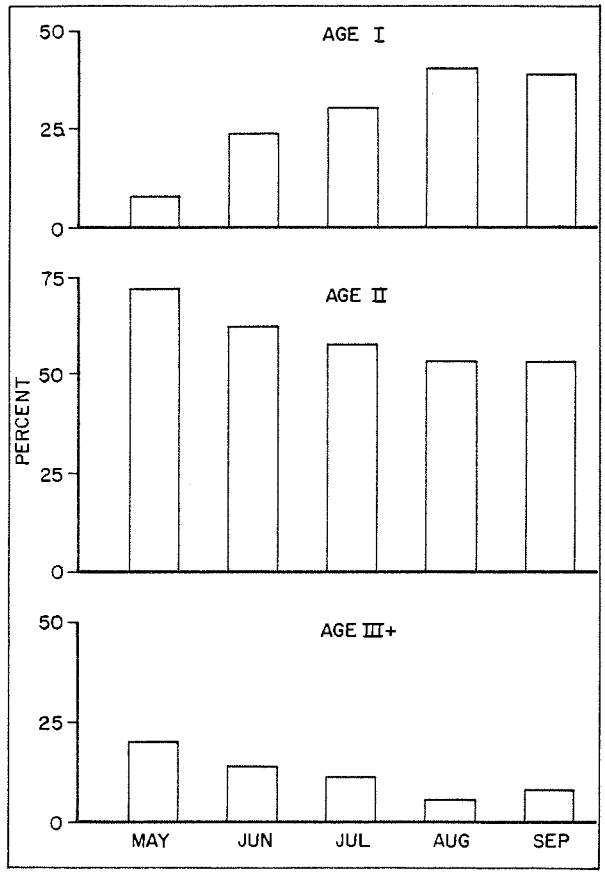


Figure 2.--Average percent composition of angler harvest, 1976-77.

by age group (table 6). Anglers harvested from 4 to 11 percent of the yearling populations in the four streams during 1976 and 1977 while the average was 7 percent. Exploitation

Table 6.--Estimated angler exploitation (%) by age group, 1976-1977

Year	Stream	Age Group I	II	III+
1976				
	Emmons Ck.	4	34	21
	Radley Ck.	10	51	13
	So. Br. Wedde Ck.	11	69	24
	Mecan R.	11	65	56
1977				
	Emmons Ck.	4	28	23
	Radley Ck.	5	34	40
	So. Br. Wedde Ck.	4	67	22
	Mecan R.	4	64	78
Grand Average		7	52	37

of age II trout ranged from 28 to 69 percent in the four streams with an average of 52 percent. Average exploitation of age III+ was 37 percent but ranged from 13 to 78 percent in the individual streams. Angler exploitation of all age groups was noticeably greater in the Mecan River and So. Br. Wedde Creek, the two streams with the lowest trout densities and highest angler use.

Angler Characteristics

Catch rates on the four streams averaged 0.6 and 0.5 trout/h during 1976 and 1977, respectively. Anglers, therefore, had to fish 1.7 h in 1976 and 2.0 h in 1977 to catch a legal trout. Forty-two percent of the anglers interviewed during the two fishing seasons captured at least 1 trout/trip. Thirty-five percent of the anglers captured at least 1 legal trout/trip.

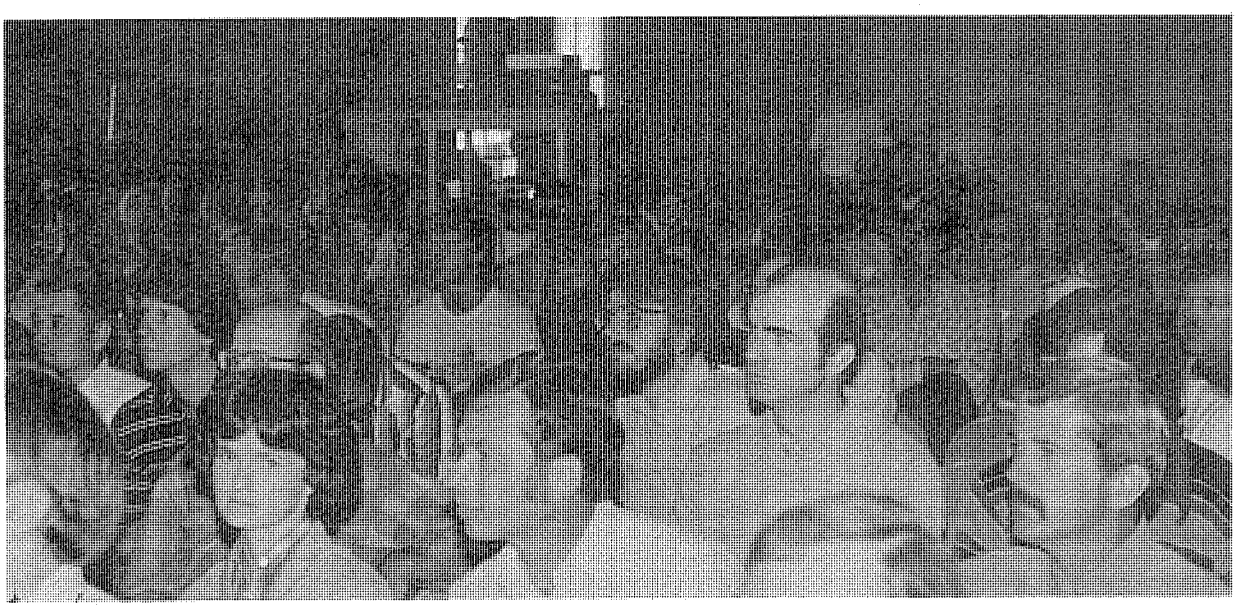
Logic dictates that the farther one travels to fish, the longer he is likely to stay to make his trip worthwhile. The average length of a fishing trip was 1.7 h on Emmons and Radley Creeks, and 2.0 h on the Mecan River and So. Br. Wedde Creek. An average of 69 percent of the anglers fishing Emmons and Radley Creeks lived within a 50-mile radius, while 61 percent of the anglers fishing the Mecan River and So. Br. Wedde Creek lived more than 50 miles away.

The three most popular bait types used by trout fisherman were worms, spinners and flies. Worms were used by 60 to 70 percent of the anglers; spinners by 15 to 20 percent; and flies by 10 percent. Few other bait types were utilized.

DISCUSSION

There is little reason to suspect that the current levels of fishing and exploitation of brown trout in the four streams in this study are seriously jeopardizing resident populations. However, the size and age structures of the populations are skewed toward smaller and younger individuals than those in less intensively fished reaches of the same streams. Sufficient number of 7- to 10- inch trout are present to maintain a challenging sport fishery.

Perhaps the most frustrating reality to anglers who have fished central Wisconsin streams for 15 years or more is the scarcity of the 16- to 18-in. trout they reportedly used to creel. It is unlikely that Class I water in this region of the state ever held significant numbers of resident trout larger than 13 or 14 in. because of the small size of the water and a food base dependent upon aquatic invertebrates. Trout larger than 18 in. were captured during fall electrofishing surveys in two of the four streams studied. These fish were rare and evidently move upstream to find spawning sites in the fall and return to the bigger and often marginal trout water downstream before spring.



RESEARCH PERSPECTIVES FOR MANAGEMENT OF

WILD STEELHEAD TROUT[1]

Carl B. Schreck[2]

Abstract.--Different stocks of wild steelhead trout (Salmo gairdneri) differ genetically; some of these differences can be correlated to differences in performance of the populations. Typological approach to steelhead management is not appropriate since stocks within the species can have different characteristics that relate to performance under different environmental conditions. The use of reproductively incompetent hatchery trout may be a means of reducing biological introgressive effects of hatchery fish on wild runs; that is, genetic purity of wild fish would be maintained. A model of performance of steelhead under various habitat elements has heuristic potential for understanding the interaction between the population and its environment.

INTRODUCTION

Steelhead trout (Salmo gairdneri gairdneri) are the ocean-going subspecies of rainbow trout (S. g. irideus) that are highly desirable sport fish in Pacific tributaries. Their stature as a recreational species has contributed significantly to the present state of wild steelhead runs: Habitat alterations in concert with sportfishing demand has necessitated their widespread propagation and release into streams formerly dominated by wild fish. Steelhead fishing is still good in many waters, for example in the Alsea River, Oregon, where 7,400 fish were landed in 1977. The problem for the wild stock arises from the fact that more than 97% of this catch was composed of hatchery fish (Garrison and Peterson 1978). Consequently, the better the fishing for hatchery and wild fish combined, the lower is the escapement of wild fish needed to secure the success of future populations. There is no need to document to this panel the effects that western land use practices such as timber harvest, road construction, grazing, water withdrawal, and dams have had on wild stocks of steelhead. What I would like to do is discuss briefly what I consider to be the major areas of research needs for steelhead and then outline some current work of my group at the Oregon Cooperative Fishery Research Unit that may help answer some of these questions from a management perspective.

I classify this research into four main categories: (1) characteristics of extant stocks in terms of genetic differences between populations and possible differences in environmental performance or tolerance limits; (2) effects of habitat alterations on recruitment-potential of impacted stocks and means of rectifying deteriorated environments; (3) potential influence of hatchery fish on fitness of wild stocks; and (4) management strategies that would prevent further deterioration of wild stocks or enhance recruitment of wild populations in the face of heavy angling pressures, hatchery fish, and habitat alterations. Objectives of research typically address more than one of these areas.

Management has been characterized by typological (no differences between stocks) thinking. Genetics of steelhead trout is of current interest (Hassler and Vankirk 1977). Research in the past few years has shown that various stocks

[1]Paper presented at the Wild Trout II Symposium, Yellowstone National Park, Sept. 24-25, 1979.

[2]Leader, Oregon Cooperative Fishery Research Unit, Oregon State University, Corvallis, Oregon 97331. Supported jointly by the U.S. Fish and Wildlife Service, Oregon Department of Fish and Wildlife, and Oregon State University. Oregon State University Agricultural Experiment Station Technical Paper No. 5313.

of steelhead are unique phenotypically, and that many of these differences have a genetic basis (Allendorf 1975; McIntyre 1976; Utter and Allendorf 1977). We have found, for example, that four steelhead stocks differed genetically in taxonomic characters and that the environment also has an effect on determining phenotype. Rogue and North Santiam hatchery steelhead differed by up to 2.9 vertebrae when reared in a common environment. When reared at their original hatcheries the environment was responsible for changing the values 2.0 and 0.7 vertebrae, respectively, from those found in their common rearing environment (Winter, Schreck, and McIntyre 1979a).

To properly manage steelhead in river basins with more than one run (such as on the Rogue River, Oregon, which has summer and winter steelhead trout), one must have knowledge about life history requirements of each race. The problem is that the juveniles cannot be readily assigned to their race, summer or winter. We attempted to characterize steelhead juveniles of several brood years from the Rogue basin as belonging to either summer or winter runs. Even though differences were found between biochemical taxonomic characters (electrophoretically-determined allele frequencies) of the wild populations within the Rogue drainage, no differences could be detected between runs. These enzyme traits included liver lactate dehydrogenase, tetrazolium oxidase, isocitrate dehydrogenase, esterase, and glucose-6-phosphate dehydrogenase and white muscle malate dehydrogenase, malic enzyme, phosphoglucomutase, alpha-glycerophosphate dehydrogenase, and phosphohexoisomerase determined in 19 samples of from 40 to 100 fish each (McIntyre et al. 1976). In a study designed specifically to detect taxonomic differences between the two runs we were unable to assign wild juvenile steelhead from the Rogue to their race with 90% accuracy--even though summer-run fish had significantly fewer vertebrae and larger nuclei, greater average intracircular spacing, and a greater length at first annulus formation of scales than did winter-trout. No differences were found for otolith nuclear diameter, total visceral fat, or muscle fatty acid composition between the two runs (Martin 1978).

The biological concept of a species, recognizing variability and unique attributes of its component populations, has management implications. As mentioned above, many of the stocks of steelhead can be recognized as taxonomic entities. It is important to consider the possibility that there may be adaptive significance correlated with, or perhaps related to, the taxonomically different characteristics. We tentatively believe, for example, that there may be differences in disease susceptibility between hatchery stocks of steelhead. Trout from the Siletz River appeared to be more resistant to bacterial kidney disease (Corynebacterium sp.), suffering 72% mortality, than were Rogue River and North Santiam stocks with 97 and 90% mortality, respectively. The Alsea stock was not significantly different (96%). Genetic factors are probably more important in determination of resistance to chronic rather than acute diseases. Vibriosis (Vibrio anguillarum) challenge caused rapid mortality, and we could find no consistent differences between the above stocks in their susceptibility (Winter, Schreck, and McIntyre 1979b). At the biochemical level, there appears to be correlation between some isozyme patterns and performance of fish with particular isozymes under various environmental variables. For example, different phenotypes of isocitrate dehydrogenase and lactate dehydrogenase in juvenile steelhead appeared to affect tolerance limits for acute thermal stress or oxygen depletion. Weight, length, and condition factor of steelhead fry also appeared to be correlated with LDH phenotype (Redding and Schreck 1979).

There appear to be latitudinal correlations between phenotypes of steelhead trout with groups proximate geographically being most similar (McIntyre 1976). If one extends some recent findings on coho salmon (Oncorhynchus kisutch) to steelhead, some relationship can be inferred between phenotype of the stock and habitat characteristics. Based on two biochemical traits (isozyme gene frequencies), two life history traits, and six morphological characteristics of about 23 coho stocks from Oregon, 3 from California, and 2 from Washington, and generally covering 2 brood years, five groups of stocks became evident: (1) wild stocks from the northern coast of Oregon; (2) wild stocks from the southern coast; (3) stocks from hatcheries using wild coho salmon for an egg source; (4) stocks from large stream systems; and (5) hatchery stocks from the northern Oregon coast (Hjort 1979). Theoretically, steelhead should follow similar patterns. Further research along these lines with steelhead stock characterization can provide a basis for selecting donor stocks to reestablish wild runs optimizing performance, by using hatchery stocks most compatible genetically with extant wild populations as suggested by McIntyre (1976) and identification of wild stocks (genotypes) with desirable adaptations for brood stock selection or other management purposes.

Little is known about the effects of hatchery fish directly on wild fish populations. Two main questions need to be resolved. Do hatchery fish compete with wild fish, thereby reducing recruitment of wild populations and what percentage of hatchery fish excapement contribute to wild spawning (Crawford 1977)?

Bieber (1977) concluded that hatchery steelhead fry were more aggressive than wild fish. Plausibly, resident fish would be displaced by the hatchery fish if the habitat was saturated. There are a number of studies determining life history and migratory habits of wild and hatchery smolts (see, e.g., Bjornn 1978). If it were determined that there was a significant amount of rearing during out-migration, then hatchery smolts could be liberated at a stage where they would move out of the stream system rapidly or at a time when there are few wild fish in the system. Hatchery fish spawning in the wild or hybridizing with wild fish may negatively influence stock-recruitment relationships of the wild population (Reisenbichler and McIntyre 1977).

Confounding the potential problem of gradual infiltration of hatchery gene pools into wild populations is the possibility that a large number of hatchery fish may be straying from streams of release to other rivers. In 1978, between 25 and 40% of the steelhead spawners in the Alsea River, Oregon, were from smolt plants made in other Oregon coastal streams (N. Peterson, pers. comm.). Factors affecting homing precision of these fish need to be determined to reduce straying.

One possible management consideration, if the objective is to minimize genetic effects of hatchery fish on wild stocks without reducing the number of hatchery fish in the system, is to create a segment of the hatchery run that has no reproductive capabilities. I am not advocating this approach here, but offer it as a plausible management option to meet the above objective. Of course, a segment of the hatchery run would have to be maintained for brood purposes. Creation of a reproductively incompetent hatchery run is theoretically feasible.

Several approaches to producing sterile fish must be evaluated. Polyploid sterility in brook trout (Salvelinus fontinalis) has been reported, and could perhaps be induced by cold-exposure of embryos (Allen 1978). Hybridization can also produce a form of polyploid sterility. Rainbow trout females x brook trout males can produce such fish (Buss and Wright 1956; Capanna 1974), but this approach does not appear to be practical for steelhead. Chemical treatment of fertilized eggs may also produce polyploid sterility; preliminary efforts with cytochalasin B on Atlantic salmon (Salmo salar) appear promising (Allen and Stanley 1979). Other chemosterilants may also be effective. Bisazir [P, P-bis (1-aziridinyl)-N-methylphosphinothioic amide] potentially affects spawning-run sea lampreys (Petromyzon marinus). Immunological methods where antisera are developed to suppress gametes also appear encouraging in tests with adult lampreys (Hanson and Howell 1978; Hanson and Manion 1978). Another possibility with encouraging results involves the administration of sex hormones immediately after swim-up. High levels of androgen, estrogen, or anti-sex hormones added in the diet during the first month or two after onset of exogenous feeding may interfere with normal sexual development. We found greatly skewed sex ratios and evidence of aberrant gonadal development in a nutrition study with steelhead from Cole Rivers Hatchery, Oregon, fed steroids to enhance their growth from swim-up to smolt stage (Table 1). Higher dosages given for a short time early in life would probably be most efficaceous. Sterile fish may also be able to channel energy into growth that may otherwise go into gonadal development. Research on performance, growth, and spawning behavior (desirably there should be none) of potentially sterile fish needs to be undertaken.

Table 1.--Percent of male, female and intersex of steelhead trout treated with methyltestosterone (MT), methyltestosterone plus diethylstilbesterol (MT+DES), diethylstilbesterol plus clomiphene citrate (DES+CC), methyltestosterone plus flutamide (MT+FL), or flutamide (FL). All treatments (except FL 20) are significantly different from control at $\alpha = 0.01$. A = data from Schreck and Evenson (1977); B = data from Sower (1978).

Treatment (μg/g of feed)	Male	Female	Intersex
Control - A	58	42	0
Control - B	61	39	0
MT (1) - A	84	14	2
MT (5) - B	100	0	0
MT (15) - B	93	0	7
MT (35) - B	77	23	0
MT+DES (5:15) - B	15	44	41
DES+CC (5:15) - B	12	73	15
MT+FL (5:20) - B	89	0	11
FL (3) - A	37	62	1
FL (20) - B	38	42	0

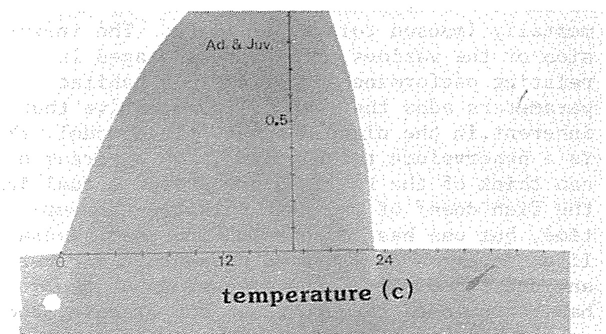
Complementing information needed on life history of wild steelhead is a need to understand the relationship of biological and physical features of the habitat and performance of trout populations. Research objectives should include developing a means of assessing the capacity of habitats to produce steelhead. If one could predict the quality of a habitat in terms of recruitment ability of populations, one could manage the river systems for enhancement or reduction of the effects of alterations. Response of fish and fish populations to various habitat factors can be monitored in several ways ranging from clinical determination of individual fish health to growth and reproduction of populations, which is the ultimate approach.

Clinical indications of the well-being of wild steelhead are extremely difficult to assess. Disease-induced problems due to environmental stressing agents can be monitored. For example, the Oregon Department of Fish and Wildlife has been monitoring Columnaris in Rogue River populations induced by elevated water temperature. Physiological characteristics of the stress response can be evaluated to determine some effects of habitat alterations, but sampling wild fish poses a problem because many physiological features are affected by the sampling technique (Bouck and Ball 1966; Schreck et al. 1976).

We have been using a clinical approach for assessing the effects of suspended sediment on steelhead fry and parr. Turbidity due to land use practices in the Northwest is of concern. Because of the migratory habits of steelhead, we coupled our physiological tests with an evaluation of the effects of suspended sediment on the ability of the fish to adapt to sea water. Steelhead fry averaging 3.3 cm in fork length (FL) were exposed in triplicate groups to 0, 0.5 or 1.5-2.5 g/L sandy loam soil. These concentrations can be encountered by wild fish; no mortality was noted during the 96 h test. Fish in all groups fed vigorously but those exposed to the highest level of sediment were more oriented towards the surface.

In a second experiment, duplicate groups of juveniles ($\bar{x}$ = 13.7 cm FL) were exposed to 0, 0.4-0.6 or 1.7-2.7 g/L suspended solids. Fish were sampled at the initiation of treatment periodically throughout the next 8 days to obtain plasma. On days 2 and 8 after being under treatment conditions, 10 fish from each group were transferred to 75% sea water; after 3 days these fish were sampled to obtain plasma. Mean plasma cortisol levels (an index to stress; Mazeaud, Mazeaud, and Donaldson 1977) were similar between replicates. Fish exposed to the highest level of suspended solids had significantly higher cortisol concentrations than did controls between 12 and 48 hours after onset of treatment. This could be due to stress during this time. The fish later acclimated to the situation, returning to control levels during the next several days. Exposure of the fish to siltation for periods of 8 days or less had no effect on osmoregulatory ability in salt water; the sediment-exposed fish were able to regulate Na^+ as competently as control fish. More details on this work, which is still in progress, is given by Redding (1979). High silt loads of coastal streams may thus not pose a problem for steelhead in terms of clinical chemistries of stress or the ability to adapt to sea water. More profound effects of suspended sediments may be manifested in terms of feeding, competition, growth, or reproductive success. Some of these aspects are being evaluated by Dr. T. Bjornn at the Idaho Cooperative Fishery Research Unit.

To gain full understanding of the performance of steelhead under various habitat conditions, one needs a characterization of habitat requirements of the fish. A simple, conceptual way of assessing the ability of the fish to perform under various habitat conditions has been developed and relates habitat conditions to fish production potential. Raleigh (1979) outlined the methodology in detail. Briefly, the values of a habitat element possibly encountered by a species is correlated with some measurement of performance of the fish under the various states of that element. Performance criteria can be in terms of standing crop, density, or survivorship. Physiological perspectives such as growth or reproductive ability are more reliable criteria. We used data from the literature to relate the freshwater physical habitat characteristics that have been measured to performance of steelhead. Since units used to assess performance differed greatly, all indices of performance have been standardized to a scale from 0 to 1.



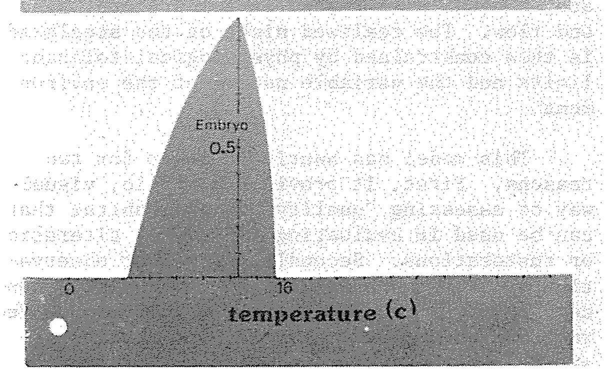


Figure 1.--Performance scaled from 0 to 1 of steelhead embryos and juveniles and adults at various temperatures. A rating of 1 on the Y-axis indicates optimum performance and a 0 indicates no performance.

If one looks at the total performance criteria for steelhead over the various habitat elements, one obtains an impression of the species' habitat requirements. Of 276 papers dealing with all stages of steelhead development that were reviewed, 61 contained usable data for determining relationships of performance with a physical habitat characteristic. We constructed the following models based on these references (the bibliography is available from the Oregon Cooperative Fishery Research Unit, Oregon State University, Corvallis, Oregon 97331): (1) Dissolved oxygen--embryos, (2) dissolved oxygen--juvenile and adult, (3) temperature--embryo, (4) temperature--juvenile and adult, (5) depth--embryo, (6) depth--0+ juvenile, (7) depth--1+ juvenile, (8) depth--2+ and 3+ juvenile, (9) minimum depth--adult, (10) velocity over redd--embryo, (11) velocity--juvenile, (12) gravel size--embryo, (13) % sand in redd--embryo, (14) substrate size--0+ juvenile, (15) substrate size--1+ juvenile, and (16) substrate size--2+ and 3+ juvenile.

All of the relationships taken together can be viewed conceptually as presenting an aspect of the fundamental niche of the steelhead (Fig. 2). One can conceptually view the niche as being defined by the fish in terms of its capacity to perform (i.e., the job that it does in the community) and is restricted by environmentally imposed tolerance limits. The inclusion of the various life history stages in relating performance under various habitat parameters adds the temporal perspective that is inherent in the niche concept. This model, then is a hypervolume through time. In a stream one can think of the realized niche (the actual job the fish does) of the fish pulsating through time, but one has to bear in mind that several life history stages can be present in a river at any one time. Also, the dimensions of the habitat pulsate through time; for example, there are seasonal differences in temperature, space, and flow. The realized niche of the steelhead is thus constrained by physiological tolerance limits and the variable nature of the environment.

This model has heuristic power for two reasons. First, it provides a simple, visual way of assessing "quality" of the habitat that can be used in evaluating impacts of alterations or restorations. Secondly, a salient observation is that there is much that is unknown concerning steelhead biology; it highlights needed research areas. For example, one obtains insight into the extreme paucity of information even in data on the parameters used in constructing the model. Most of the curves were drawn following subjective evaluation of the plotted data. To date, only physical habitat elements have been studied. Even in these one readily notes the absence of data on many key habitat elements such as cover, frequency of flooding, and ionic composition of the water. Also lacking is any basis for evaluating interactive effects between habitat elements. Most striking is the complete absence of information on the biological attributes of the environment. One has no way of determining the importance of competition, predation, primary and secondary production of the stream, and species composition to the ability of a habitat to produce steelhead. The importance of the biological aspects of the habitat relative to the physical elements for the production of steelhead also needs to be determined. Since various stocks do not necessarily have similar tolerance limits or performances, this typological approach should be replaced subsequently with more detailed models, perhaps on a more regionalized level or based on some other taxonomic classification scheme.

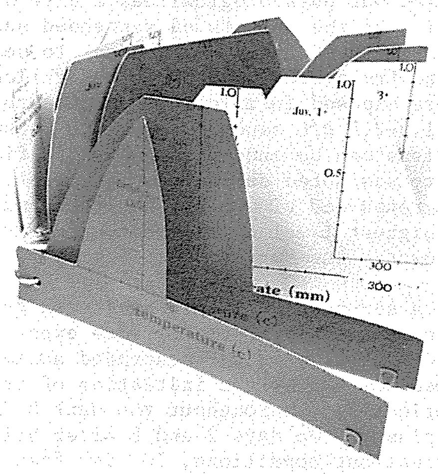


Figure 2.--Habitat element-steelhead trout performance model for the 16 relationships given in the text. The model depicts eight habitat elements, some of which have been related to more than one life history stage.

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LITERATURE CITED

Allen, S.K. 1978. Reproductive sterility in polyploid brook trout. Maine Coop. Fish Res. Unit Annu. Rep., Orono, Maine.-5.

Allen, S.K., and J.G. Stanley. 1979. Polyploid mosaics induced by cytochalasin B in landlocked Atlantic salmon Salmo salar. Trans. Am. Fish. Soc. 108:462-466.

Allendorf, F.W. 1975. Genetic variability in a species possessing extensive gene duplication: Genetic interpretation of duplicate loci and examination of genetic variation in populations of rainbow trout. Ph.D. Thesis. Univ. Washington. 98 p.

Bieber, G.F. 1977. Comparative behavior of the progeny of hatchery and wild steelhead trout (Salmo gairdneri). M.S. Thesis, Oregon State Univ., Corvallis. 32 p.

Bjornn, T.C. 1978. Survival, production, and yield of trout and chinook salmon in the Lemhi River, Idaho. College Forestry, Wildl., Range Sci., Univ. Idaho. Bull. No. 27. 57 p.

Bouck, G.R., and R.C. Ball. 1966. Influence of capture methods on blood characteristics and mortality in the rainbow trout (Salmo gairdneri). Trans. Am. Fish. Soc. 95:170-176.

Buss, K., and J.E. Wright. 1956. Results of species hybridization within the family Salmonidae. Prog. Fish-Cult. 18:149-158.

Capanna, E. 1974. An intergeneric hybrid between the rainbow trout and the freshwater char (Salmo gairdneri x Salvelinus fontinalis). Boll. Pesca Discic Idriobiol. 29:101-106.

Crawford, B.A. 1977. A study of the contribution of hatchery-reared summer steelhead to wild steelhead recruitment through the use of genetic markers, p. 16-19. In: T.J. Hassler and R.R. Vankirk (eds.). Proceedings of the genetic implications of steelhead management symposium. Calif. Coop. Fish. Res. Unit, Spec. Rep. 77-1.

Garrison, R.L., and N. Peterson. 1978. Stock assessment and genetic studies of anadromous salmonids. Federal Aid Prog. Rep.-Fish. Oregon Dept. Fish Wildl. AFS-73-1. 41 p.

Hanson, L.H., and J.H. Howell. 1978. Alternative methods of sea lamprey control: Development of methods to sterilize sea lampreys. Great Lakes Fish. Lab., U.S. Fish Wildl. Serv., Prog. Fish. Res. 1976-77:64-68.

Hanson, L.H., and P.J. Manion. 1978. Chemosterilization of the sea lamprey (Petromyzon marinus). Great Lakes Fish. Comm. Tech. Rep. No. 29. 15 p.

Hassler, T.J., and R.R. Vankirk. 1977. Proceedings of the genetic implications of steelhead management symposium. Calif. Coop. Fish. Res. Unit, Spec. Rep. 77-1. 57 p.

Hjort, R.C. 1979. Phenotypic comparison of hatchery and wild coho salmon (Oncorhynchus kisutch) in Oregon, Washington, and California. M.S. Thesis, Oregon State Univ., Corvallis. 50 p.

Martin, J.T. 1978. Racial identification of chinook salmon (Oncorhynchus tshawytscha) and juvenile steelhead trout (Salmo gairdneri). M.S. Thesis. Oregon State Univ., 32 p.

Mazeaud, M.M., F. Mazeaud, and E.M. Donaldson. 1977. Primary and secondary effects of stress in fish: Some new data with a general review. Trans. Am. Fish. Soc. 106:201-212.

McIntyre, J.D. 1976. The impact of interbreeding of artificially propagated and native stocks of steelhead trout: Project A. Genetic differences between natural and artificially propagated steelhead trout. Annu. Prog. Rep. Anadromous Salmonids. Res. Sec., Oreg. Wildl. Comm. p. 22-24.

McIntyre, J.D., C.B. Schreck, C. Kristiansson, J.M. Redding, and M. Solazzi. 1976. Biochemical genetic variation in Rogue River chinook salmon (Oncorhynchus tshawytscha) and steelhead trout (Salmo gairdneri). Rogue Basin Evaluation Prog. Annu. Rep. Pt. 2, Oregon Dept. Fish Wildl. 61 p.

Raleigh, R.F. 1979. Trout stream habitat improvements: Diagnosis and design. Wild Trout II Symposium--this proceeding.

Redding, J.M. 1979. Chronic turbidity and stress in juvenile coho salmon and steelhead trout. Oreg. Coop. Fish. Res. Unit Annu. Rep. 1978-79:16-36.

Redding, J.M., and C.B. Schreck. 1979. Possible adaptive significance of certain enzyme polymorphisms in steelhead trout (Salmo gairdneri). J. Fish. Res. Board Can. 36:544-551.

Reisenbichler, R.R., and J.D. McIntyre. 1977. Genetic differences in growth and survival of juvenile hatchery and wild steelhead trout, Salmo gairdneri. J. Fish. Res. Board Can. 34:123-128.

Schreck, C.B., and M.D. Evenson. 1977. Anabolic steroids: Effects on anadromous salmonids. Part I. Winter steelhead at Cole Rivers Hatchery. Oreg. Coop. Fish. Res. Unit Annu. Rep. 1976-77:216-219.

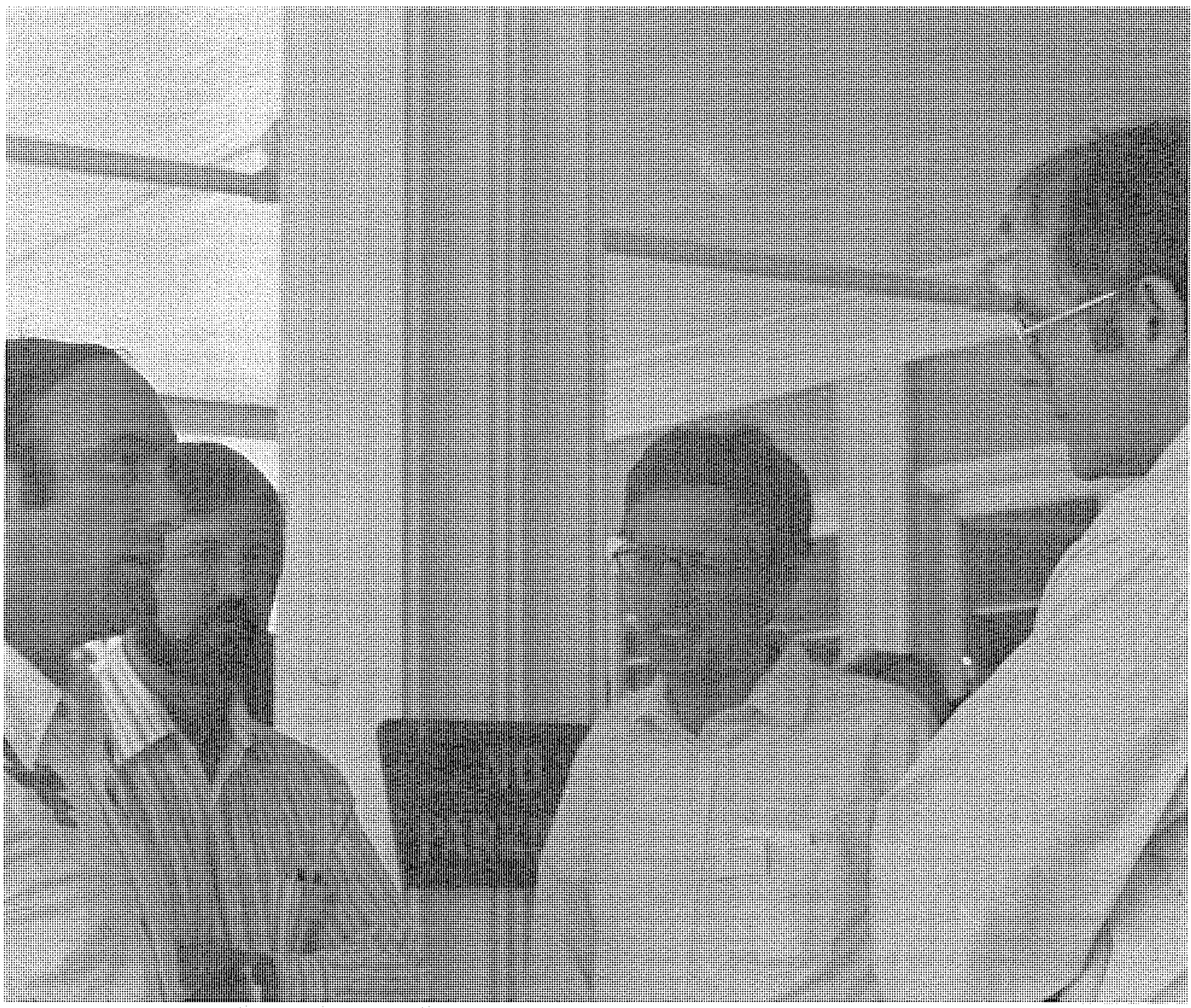
Schreck, C.B., R.A. Whaley, M.L. Bass, O.E. Maughan, and M. Solazzi. 1976. Physiological responses of rainbow trout (Salmo gairdneri) to electroshock. J. Fish. Res. Board Can. 33:76-84.

Sower, S.A. 1978. Growth and precocious development of steelhead trout: Effects of hormonal compounds. M.S. Thesis. Oregon State Univ., Corvallis. 41 p.

Utter, F.M., and F.W. Allendorf. 1977. Determination of the breeding structure of steelhead populations through gene frequency analysis, p. 44-54. In: T.J. Hassler and R.R. Vankirk (eds.). Proceedings of the genetic implications of steelhead management symposium. Calif. Coop. Fish. Res. Unit, Spec. Rep. 77-1.

Winter, G.W., C.B. Schreck, and J.D. McIntyre. 1979a. Meristic comparison of four stocks of steelhead trout (Salmo gairdneri). Copeia: In press.

Winter, G.W., C.B. Schreck, and J.D. McIntyre. 1979b. Resistance of different stocks and transferring genotypes of coho salmon and steelhead trout to bacterial kidney disease and vibriosis. U.S. Natl. Mar. Fish. Serv. Fish. Bull. 77:In Press.



HABITAT PANEL

Discussion Leader

John Nickum
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Introduction: As Nat Reed pointed out in his keynote statement, what man does in and to his environment determines not only his future but that of all living creatures. This basic premise pervades our Symposium and especially the papers and discussions of this panel. We are searching for knowledge and wisdom so that we may leave aquatic habitats in the best possible condition, not only for trout but for succeeding generations of the human race to enjoy.

The subject is approached from several major directions. The importance of vegetation in maintaining quality in water and soils; the necessity for pertinent and enforceable legislation and regulations; specific examples of relationships between habitat changes and species response, for example: direct effects of pollution such as acid rain; forestry and agricultural practices; and criteria for improving the physical environment in streams. The panel does not promise to provide solutions to all problems, but does leave no doubt that our concern for a livable environment is basic, if wild trout are to remain on this planet in the decades before us.

LIVESTOCK GRAZING AND LOGGING EFFECTS ON TROUT[1]

William S. Platts

and

Susan B. Martin[2]

Abstract.--This paper discusses the influence of livestock grazing and timber harvesting activities on trout and their environments. Specific pollution effects on stream habitat and water quality resulting from such development are discussed. Present and future management of the resource is summarized, and suggestions for future management of both livestock and logging are suggested.

INTRODUCTION

Range and forest lands are managed as lands for many uses. This classification encompasses the streams and riparian environments on such lands. Therefore, range and forest management determines the quality of riparian-stream management because management guides do not adequately consider the smaller subsystems as individual units for management. Often, what is good management for grazing and logging is not good management for trout.

RANGE EFFECTS

Several studies document the historical background on the use of public ranges for livestock grazing (Adams 1975, Platts 1978a, U.S. Senate 1936). These studies show that much of the rangeland has been depleted of natural and desirable vegetation, affecting runoff and sediment accrual and transport rates. The nonriparian part of the range ecosystem has improved in recent years (Hormay 1970), but the riparian-stream systems have continued to decline (Townsend and Smith 1977). This decline occurred because fishery biologists were not well informed about grazing-fishery interactions and because land managers were unaware of or failed to heed predictions of ongoing habitat destruction. Some land managers failed to recognize that streamside environments are different from other terrestrial environments and so require specialized management.

Today decision-makers include management of riparian zones in their plans, and scientists are developing good data banks on livestock-fishery interactions. These are encouraging trends and will improve livestock and riparian management.

Present Management

Streams and adjacent habitats compose the most productive ecosystem within the range classification. Since livestock concentrate along these streamside zones, excessive use often results. This excessive use has caused many environmental problems. Today's range management guidelines may not solve these problems because they do not present strategies for handling different habitat types; these guidelines cover only broad combinations of lands that mix riparian zones with upland zones. Better balance of resource management is complicated because scientists still differ in their interpretation of the effects of grazing strategies on stream and riparian habitats. Moreover, grazing land is continually being reduced; this reduction conflicts with

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the projected need for an additional 70 million acres of range within the next 25 years to meet the growing demand for red meat. Management must meet the increasing and conflicting demands for energy, recreation, high quality water and for more red meat.

In an extensive literature review, Meehan and Platts (1978) were unable to identify any widely used grazing strategy that is compatible with the environmental needs of streams. Modifying existing grazing strategies or developing new strategies that will have environmental compatibility will be difficult. The problem becomes more difficult when practices other than grazing alter streams and streamside environments.

Most of today's grazing strategies are based on grazing selected pastures with grazing and rest periods set at yearly intervals. The systems vary depending on the livestock operations and on the type and condition of the rangeland. Five strategies (grazing systems) have come into common usage which better distribute livestock and provide for better plant growth and vigor: season-long grazing, rotation grazing, deferred grazing, deferred rotation grazing, and rest-rotation grazing. Rest-rotation grazing is most popular at present. This system produces closely cropped, well trampled vegetation for short periods. Trampling helps plant regeneration by planting seeds. This system provides a more uniform use of forage resources through better livestock distribution. Some recent thinking is that rest-rotation grazing may be harmful to other land uses (Meiners 1974). Rest-rotation can be made compatible with the riparian-stream ecosystem, but land managers will have to recognize and implement practices that protect streams and their riparian environments.

Livestock Effects

Livestock grazing can affect all four components of the aquatic system: streamside vegetation, stream channel morphology, quality of the water column, and the structure of the soil portion of the streambank. Livestock grazing can cause annual microchanges in the environment that can accumulate over many decades. These subtle changes are difficult to detect and measure. Authors have already listed the effects of livestock grazing on fish and on the aquatic environment (Platts 1978a). Livestock grazing the vegetation cover and caving in overhanging streambanks is one of the principal factors contributing to the decline of native trout in western streams.

Cattle

Because answers as to the effects of grazing on trout habitat and populations are vague, a controversy still exists. Scientists take both sides of the issue with some maintaining that there are no detrimental effects from certain types of livestock grazing. Heady and others (1974) state that livestock grazing is being managed and integrated with other uses of Federal lands. They report that well-managed grazing of domestic livestock can be compatible with a high quality environment. Hayes (1978) concluded that a rest-rotation grazing system in the meadows he studied did not significantly accelerate channel movement.

Gifford (1975) discussed some beneficial effects of range improvement practices on runoff and erosion. Lorz (1974) found no difference in fish populations in ungrazed versus grazed sections of the Deschutes River, Oregon, when dense willow cover was on one or both banks.

A complete review of the literature (Meehan and Platts 1978), however, shows that streams modified by cattle grazing are wider and shallower than these streams would have been naturally. Generally, their channels contain more fine sediment, streambanks are more unstable, banks are less undercut, and higher summer water temperatures occur than in undisturbed streams.

Three years after a stream area was fenced to exclude cattle, Van Velson (Armour 1977) reported that Otto Creek, Nebraska, had improved from a nonproducer to a major producer of trout. The stream width decreased, streambanks quickly stabilized, and summer water temperatures were reduced by 2° to 5°F (1° to 3°C). Clair and Storch (In Press) found within an exclosure on the Deschutes River, Oregon, that over a 10-year period of nongrazing the fish population shifted from predominately dace (Rhinichthys sp.) to rainbow trout (Salmo gairdneri Richardson). Marcuson (1977) in Rock Creek, Montana, found that brown trout (Salmo trutta Linnaeus) biomass per unit area in a stream within a nongrazed section was 340 percent higher than an adjacent stream section that was heavily grazed. In the same stream, Gunderson (1968) found trout were 27 to 400 percent more abundant in ungrazed sections than in grazed. Kennedy (1977) reported that trout numbers were 240 percent higher in ungrazed sections of an Oregon stream than in grazed sections. Duff (In Press) found trout populations 360 percent higher in ungrazed reaches of Big Creek, Utah, than in grazed stream reaches. Lorz (1974) reported that trout populations were about 350 percent higher in ungrazed sections of the Little

Deschute River, Oregon, than in grazed sections. These studies strongly suggest that improper cattle grazing reduces fish numbers.

Sheep

In evaluating the effects of livestock grazing on the aquatic environment, it must be recognized that different classes of livestock have different use preferences in regard to streamside environments. Sheep prefer slopes and upland areas; cattle prefer riparian habitats. A large amount of former sheep range has been converted to what is primarily cattle range. Because cattle prefer streamside environments, deterioration of riparian habitat has been and still is significant. Also, sheep are herded while cattle are usually left alone to determine their own position on the range. Therefore, proper sheep grazing has more potential for utilizing nonriparian forage and eliminating direct effects on trout habitat. At present, little data exist to support this statement.

Platts studied a meadow heavily grazed by sheep in the Sawtooth National Recreation Area near the headwaters of the Salmon River. The meadow was used for forage during a September holding period while sheep were awaiting shipment. An adjacent meadow site was studied that had been a Forest Service administrative site since 1910; so over the past 70 years, the meadow had only minor amounts of sheep grazing.

The main differences between the stream running through the two meadow sites were in the streambanks, stream width, stream depth, and vegetative cover. Streambanks in the grazed areas were set back away from the stream and outsloped. The angle or slope of the bank away from the water surface was much higher. The banks had little undercut in the grazed area. Average stream width was four times as wide in the grazed area as in the ungrazed area. Average stream depth was almost five times as great in the ungrazed site versus the grazed site. The depth of the stream at its interface with the streambank was almost 13 times as great in the ungrazed area as in the grazed. The heavy sheep use on the streambank through time widened the stream and made it much shallower.

Also, in the Sawtooth National Recreation Area near the headwaters of the Salmon River, Platts (1978b) studied two sites in sheep range being managed under a deferred grazing system with herding. This study showed that sheep grazing under proper management has insignificant effects on the stream and its fisheries (unpublished data on file at Intermountain Forest and Range Experiment Station). Sheep can be herded and controlled and do not necessarily favor the riparian zone. Possibly they could forage on allotments when riparian zones are badly degraded or contain critical fish habitats.

Management Guidelines

Present streamside management varies between agencies, divisions within agencies, and especially between public and private land ownership. Management direction is given to land management agencies through laws, regulations, manuals, land use plans, and allotment guides. This managment direction generally requires environmental protection of soil, water, and air. Recently, agencies have been given additional guidance through Section 208 of Public Laws 92-500 and 95-217. These laws give definite guidance to nonpoint source pollution.

A Livestock-Fishery Interaction Workshop (Menke In Press) rated some of the most commonly used grazing strategies as follows:

	Grazing System	Condition of resulting riparian-aquatic habitat
1.	Year-long	Poor
2.	Season-long	Poor
3.	Deferred	Poor to fair
4.	Rotation	Poor to fair
5.	Deferred-rotation	Poor to fair
6.	Rest-rotation	Poor to variable[3]
7.	Short duration, high intensity	Variable[3]
8.	None	Good to excellent

Based on this analysis, present range management guidelines need improvement.

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[3]Resource damage, especially bank cutting, within heavy use units may be repaired within the grazing cycle.

Future Needs

Land managers are setting types of grazing systems, levels of forage use, and classes (cattle, sheep) of livestock use. Fisheries managers are establishing fish harvest and regulations for aquatic habitat protection. Neither land nor fisheries managers have enough information to understand livestock-fish habitat relationships or to determine whether grazing systems are causing stress on riparian or aquatic systems. They also need guidance in effective ways to correct problems.

Livestock grazing studies primarily address the effects on water runoff and soil erosion on slopes. Seldom have they considered the relationships between livestock grazing and the aquatic environment. Thus, even though livestock use on western ranges has passed the 100-year mark, the relationship between grazing and aquatic resources is just beginning to be understood. And, understanding is a must if land managers are to successfully manage riparian and aquatic environments.

To evaluate the influences of different livestock grazing systems, biologists need methodologies that will detect, within narrow confidence intervals, the natural variation in streamside vegetation, in streambank and stream channel conditions, and in fish standing crops and community structure. The need to increase the amount of data collected, reduce error in measurement, and develop new ways to describe environmental conditions indicates problems in our methodology. Fishery biologists must solve these problems before they can meaningfully analyze livestock-fishery interactions.

Using valid methodology the fishery scientist working with range, soil, and hydrology scientists should attack the problems by individual components, by relationships among components, and by the total system. The effects of livestock grazing on each component should be thoroughly understood prior to analysis of effects on the complete system.

Streamside Vegetation

Vegetation studies should assess the canopy cover needed for acceptable water temperatures, for soil stability, for lessening trampling by livestock, and for maintaining fish cover. Studies should also indicate the plants best adapted for recolonizing degraded riparian habitats and what part the different riparian vegetative types play in stabilizing streambanks.

Streambanks

Studies are needed to determine the amount of trampling streambanks of certain soil types can take before breaking down, how long it takes streambanks to rehabilitate under improved management systems, and what effect offset, outsloped banks have on the fishery.

Water Column

Studies are needed to determine the influence of livestock on water quality, and pool-riffle structure.

Stream Channel

Studies need to identify the effects of livestock on streambanks, channel form, and on trout redds.

Once the component effects and their relationships are identified then the complete system should be studied to determine overall effects such as:

1. How much, if any, of the fish population is lost because of livestock grazing streamside areas?
2. What are the first indicators that a stream is beginning to deteriorate or to improve from management of livestock?
3. How long does it take a stream altered by livestock to return to pregrazing conditions?
4. What techniques are available to reduce the recovery time for degraded streams?

With analysis of effects on the complete ecosystem the information developed will allow us to address such areas as:

1. Which of the existing grazing systems are most compatible with the fishery resource?
2. Is there an ideal livestock grazing strategy for riparian areas?
3. What part can fencing play in protecting critical habitats?
4. How do different classes of livestock affect the riparian environment?
5. During what period of the grazing season is it best to use the forage in the riparian zone?
6. What grazing strategies will provide the best protection to brushy vegetation?
7. Can depleted riparian-stream ecosystems be restored through present grazing systems?

When these answers are available, we will be in a better position to determine the optimum mix of riparian vegetation and streambank structure needed by the fishery and to properly allocate the use of these components to livestock, fish, and other users. This will provide a basis for better range and fisheries management.

Leopold (1974) at Wild Trout Management Symposium I, stated that livestock grazing may be having cumulative ill effects on productivity of both lands and waters. Leopold admitted this hypothesis was intuitive, with little factual data to back up his statement, and pleaded for studies to clear up the issues. Since 1974, awareness has built considerably, but the studies Leopold was pleading for have failed to materialize. We do have some good information to manage the riparian-stream ecosystem and this should be used. For proper management, however, we will have to heed Leopold's plea; his statements are as valid today as they were 5 years ago.

McGowan (1976) expresses doubts that present grazing strategies are capable of solving present grazing problems in the aquatic environment. If this assessment is valid, interdisciplinary teams must enter into an effort that will result in workable grazing strategies. When these strategies are available to the resource manager, rangeland decisions can be made with optimum consideration and understanding for wild trout.

LOGGING EFFECTS

Nearly 500 million acres (203 million hectares) in the United States are in forests managed primarily for timber production. The streams draining these lands are subject to modification and pollution that often result from logging activities.

Timber harvesting often occurs on small headwater streams with fragile ecosystems that are readily affected by changes in any of their aquatic components. Downstream pollution of larger streams generally results. Each fish species has an optimum set of environmental conditions for survival and any deviation from these optimums may result in stress on the species and its reproduction, survival, growth, and population density. A discussion of potential changes in the aquatic system due to logging activities and their probable effects on the fisheries follows.

Present Management

There are several cutting practices used in silviculture that can be generally categorized as thinning and final harvest. Thinning is cutting in immature stands to stimulate growth of remaining trees, and includes precommercial and commercial thinning. Logging equipment is necessary for commercial thinning; so some effects on water quality may result.

Final harvest of trees may be by cutting for shelterwood, seed tree, clearcut, or select cut. Each method affects water quality to a certain extent.

The shelterwood system requires stand removal in a series of cuts. It is well adapted where protective cover is needed or where the shelterwood inhibits growth of undesirable vegetation. Shelterwood cutting may be damaging to water quality since several entries are required, extending the period of surface erosion risk.

Seedcutting removes nearly all the timber in an area in one cut, leaving several healthy trees scattered throughout the cut for natural seeding. This method works only for species with wind seed dispersal, and even then with limited success. Impacts on water quality are similar to those from clearcutting, and are discussed below.

Clearcutting involves the complete removal of timber over a given area in a single cut. This method is highly cost-effective from the marketing standpoint, but is also the most damaging to aquatic habitat. The impacts of clearcutting on water quality are mainly site exposure, soil disturbance, and accumulation of residual material (slash). The added exposure of the site to climatic extremes can cause increased erosion and significantly alter temperature regimens. Any clearcutting method requires logging equipment, which also disturbs the site. Logging debris can accumulate in ravines and streams, leading to organic inputs and damming of streams.

Select cutting may be to harvest single trees or a group of trees. There is little slash associated with select cutting, but water quality may be damaged by soil disturbance caused by several entries into the stand.

Logged areas may be regenerated by natural or artifical seeding or by planting seedlings. These practices all require some site preparation and may cause additional damage to stream water quality.

It is the actual removal of logs that is the most damaging to water quality. Yarding logs and road construction expose sites to climatic extremes and increase the potential for soil erosion. Several yarding methods are available, ranging from the most commonly used tractor skidders to the expensive balloon and helicopter methods. For further reference, a publication by Pearce and Stenzel (1972) contains a good description of logging practices.

Logging Pollution

Potential pollution of trout habitat resulting from logging activities may take any or all of the following forms:

1. Streamflow alteration
2. Changes in water temperature
3. Changes in dissolved oxygen levels
4. Increases in sediment levels
5. Debris and organic material additions
6. Nutrient additions
7. Chemical additions

Due to the dynamic interacting nature of aquatic systems, changes in one of these parameters may result in changes in another.

Streamflow Alteration

Removal of forest vegetation by logging can increase runoff. Studies in New Hampshire, North Carolina, and West Virginia have shown that removal of all vegetation on a forested watershed increased annual water yield the first year after treatment from 9.8 to 16 inches (25 to 41 cm) (Douglass and Swank 1975, Hornbeck and Federer 1975). Water yield increases with selective cutting were considerably smaller (Hornbeck and Federer 1975, Lynch and others 1975). Yield increases declined rapidly with regrowth of vegetation. Five years after clearcutting, water yield increases may be down by two-thirds, and after 10 years most of the yield increase will have disappeared (Lull and Reinhart 1967). Cutting vegetation may also result in peak storm increases of 10 to 20 percent for moderate- to high-intensity storms, and increased storm flow volumes up to 0.5 inch (1.3 cm) (Lynch and others 1972, Patric 1973).

These increases in stream flow may have both beneficial and adverse affects, depending upon their timing, duration, and volume. Greater stream discharges during low summer flows could result in increased survival and growth of trout (Packer 1957); however, increased stream velocities could result in more erosion and stream scouring, which could depress stream biota. If the frequency and intensity of increased discharges are great enough, the benthic community can be reduced (Hoopes 1975). Stream scour may also result in damage to fish redds in the gravel.

The effects of increased streamflows would be short term as vegetation regrew to precutting densities.

Water Temperature

Since direct solar energy is the principal source of heat to small headwater streams, removal of the vegetative cover from a stream may result in significant changes in stream water temperature. Such streams are commonly used for salmonid spawning and rearing; so direct effects on fish may result.

In an Oregon logging clearcut, Hall and Campbell (1968) found a maximum stream temperature of 86°F (30°C) and a maximum diurnal fluctuation of 61°F (16°C). Comparable prelogging maximums were 61°F (16°C) and 35°F (1.5°C), respectively. Elimination of stream cover may also effect stream winter temperatures. Eschner and Larmoyeux (1963) found that the average maximum stream temperature in a clearcut was 8°F (4°C) higher than in a control stream during the growing season. The average minimum stream temperature during the dormant season was 4°F (2°C) lower in the clearcut watershed than in the control area. More recent information supports these early studies (Aubertin and Patric 1974). Studies conducted in eastern experimental forests have shown that maximum water temperature increases in an average growing season ranged from 6° to 10°F (3.3° to 5.6°C) following clearcutting (Kochenderfer and Aubertin 1975, Lynch and Others 1975).

Brown and Krygier (1967) reported that removal of streamside vegetation increased the mean monthly maximum temperature 14°F (8°C) on a clearcut watershed in Oregon's Alsea River basin. They also marked a mass of water with fluorescent dye and noted that its temperature increased 16°F (9°C) in 1 hour as it passed through a clearcut. Green (1950) observed the cooling effects of streamside vegetation on stream temperatures and reported a 12°F (7°C) decrease as a stream meandered 400 feet through forest and brush cover.

Various logging practices may affect stream temperatures differently. In studies of the Alsea Watershed in Oregon, Brown and Krygier (1970) found no increases in stream temperature when an area was cut in a patchwork manner, where buffer strips remained to shade the stream. Stream temperatures in a clearcut area, however, increased by 14°F (8°C) for the mean monthly maxima and by 28°F (16°C) for the annual maximum.

Reduced streamside cover may also affect intragravel water temperatures. Ringler and Hall (1975) found that both the mean temperature and diel fluctuation within the gravel increased in relation to reduced cover. On clear days, an intragravel maximum of 70°F (21°C) was recorded.

Studies indicate that intragravel and stream temperature changes can affect the metabolic rate of fish, decrease dissolved oxygen content, influence hatching and development, and affect migration (Lynch and Others 1977). Reduced growth, vigor, and disease resistance are probably the main effects of high water temperatures on fish.

Increased intragravel temperatures may severely affect developing eggs and alevins. Chinook salmon (Oncorhynchus tshawytscha (Walbaum)) alevins reared several weeks beyond complete yolk absorption showed substantial mortality increases at temperatures above 54°F (12°C) (Eddy 1972). In addition, a 1°F (0.6°C) increase in the optimum brook trout (Salvelinus fontinalis (Mitchill)) incubation temperature of 39°F (4.4°C) may cause eggs to develop sooner (Lynch and Others 1977), which may result in stressed fry and in emergence to unfavorable environmental conditions.

Subtle, long-term effects of temperature change on fish populations may also result. As temperatures increase, there may be a gradual shift in composition from game fish to undesirable nongame fish more tolerant of higher temperatures.

Dissolved Oxygen

Dissolved oxygen, like temperature, is a primary regulator of biological activity in an aquatic ecosystem. Dissolved oxygen in a stream is a function of water temperature and channel characteristics. Several forestry practices directly or indirectly affect stream oxygen levels. These include changes in water temperature, increases in nutrient concentration, and the accumulation of logging debris in the stream. Intragravel dissolved oxygen levels may also be affected by these factors and by increased sediment concentrations that often result from logging activities.

Water temperature and dissolved oxygen are directly related. As water temperature increases, oxygen concentration in the water decreases. Thus, any practice that increases stream temperature decreases stream dissolved oxygen levels (Churchill and Others 1962).

Accumulation of logging debris in stream channels is common, especially if logs are yarded across them. Fine debris such as needles, leaves, and bark contain large amounts of simple sugars that leach into the stream. These nutrient sources are acted on by aquatic microorganisms that use dissolved oxygen from the stream in their metabolism (Ponce 1974), reducing that available for fish. Accumulation of debris may also cause damming, which results in lower dissolved oxygen because of reduced reaeration.

Reduction of dissolved oxygen in stream gravels may have significant effects on developing salmonids. Coble (1961) found a positive correlation between intragravel dissolved oxygen and survival of trout eggs.

In an Alaskan stream, the largest and fastest developing embryos and alevins of pink salmon (Oncorhynchus gorbuscha (Walbaum)) come from spawning gravel characterized by high levels of dissolved oxygen (Wells and McNeil 1970). Coho salmon fry (Oncorhynchus kisutch (Walbaum)) incubated at low levels of intragravel dissolved oxygen were found to be less successful in competition in artifical streams than those incubated at high oxygen levels (Mason 1969). Because a large majority of emerging coho fry leave the redd area within a few months of emergence, they may compete later with stronger fish that developed at higher oxygen levels. This can have subtle, long-term effects on fish survival.

Alderice and others (1958) found that oxygen requirements for chum salmon (Oncorhynchus keta (Walbaum)) eggs were highest during early development, decreased slightly, and then rose to a constant level. Fry size at hatching and pre-emergent survival were also affected by dissolved oxygen concentration and intragravel flow. Mason (1969) found that coho salmon embryos and fry exposed to 3-5 mg/liter dissolved oxygen were smaller at hatching and emergence and had higher mortality during development than those exposed to 11 mg/liter dissolved oxygen.

Herrmann and others (1962) reported the growth rate of juvenile coho salmon decreased when dissolved oxygen was reduced from 8.3 to 5 mg/liter. Mortality increased and survivors lost weight when dissolved oxygen levels were reduced to 2.1-2.3 mg/liter dissolved oxygen.

Hall and Lantz (1969) found a dissolved oxygen concentration of 0.6 mg/liter in a debris pool. When the debris was removed, surface water dissolved oxygen concentration returned to normal. Intragravel oxygen concentrations remained 3.0 mg/liter lower than prelogging conditions and declined to less than 2.0 mg/liter in some places. This decline was attributed to decomposing organic material in the gravel and to reduced intragravel circulation caused by siltation.

Sediment Levels

Increased sediment deposition is the major aquatic pollution problem resulting from logging activities. Actually, the increased sedimentation is more directly related to the construction of roads and skid trails than to the logging itself. Likens and others (1970) found little or no increase in stream channel sedimentation when an area was totally clearcut, but no timber removal was made. When logging is done in a careful, planned manner on suitable sites no serious erosion or damage to water quality occurs (Hornbeck 1968, Lynch and Others 1972).

The type of logging practice used affects sediment production. Maximum stream turbidities were significantly increased on a clearcut watershed, but no significant increases were apparent on watersheds that were intensively select-cut (Lantz 1971, Hornbeck 1967). Brown and Krygier (1971) showed high lead logging did not result in significant increases in sediment concentration. Other studies illustrated that properly constructed skid trails produced 55 lb/acre (62 kg/ha) of sediment, while steep gradient trails with no water bars produced 433 lb/acre (485 kg/ha), almost eight times as much (Trimble and Weitzman 1953).

Unfortunately, past logging operations have sometimes caused significant erosion and stream sedimentation. Lieberman and Hoover (1948) found suspended sediment content in streams averaged 94 mg/liter with a maximum of 3500 mg/liter during logging, while sediment content in unlogged areas averaged 4 and 80 mg/liter. Reinhart and Eschner (1962) recorded maximum stream sediment of 56,000 mg/liter in an area of poorly located and constructed skid trails. Other authors have reported that substantial increases in stream channel sediment have resulted from logging (Megahan and Kidd 1972).

Slash burning may ultimately affect stream sediment levels. Packer and Williams (1974) reported burning decreased ground cover and increased overland flow of water by at least two times. Brown and Krygier (1971) found a fivefold sediment increase following clearcutting and burning.

The effects of sedimentation on salmonid spawning habitat have been extensively studied. Harrison (1923) correlated increases in egg and fry mortality with a decrease in size of particles making up the salmon redd. Shapovalov (1937) found reductions of 50.1 and 38.0 percent in survival-to-emergence of steelhead trout (Salmo gairdneri Richardson) and coho salmon eggs in heavily silted gravel. The smothering effect of silt and sand was cited as the cause of high egg mortalities by Gangmark and Broad (1955) and Platts (1970).

McNeil and Ahnell (1964) found an inverse correlation between number of adult pink salmon returning to six Alaska streams and the percentage of gravel less than 0.03 inch (0.833 mm) particle diameter. They also concluded that productive spawning habitat should contain no greater than 5 percent fines of 0.03 inches (0.833 mm) or smaller, and that gravels were nonproductive if they were composed of 30 percent or more small fines. Survival-to-emergence of coho salmon and steelhead trout in three Oregon streams ranged from 0 to 83 percent, with survival significantly decreased in gravels smaller than 0.5 inch (13 mm) diameter (Phillips and Others 1966).

Bjornn (1969) studied the effects of sand on steelhead trout and chinook salmon eggs. He found that steelhead survived higher percentages of sand than salmon and concluded that mortality of embryos in gravel with 30 to 40 percent sand was 50 percent for chinook salmon and 30 to 50 percent for steelhead trout.

Koski (1975) found that emergence and fry fitness of chum salmon were related to percentage of sand (0.004 to 1.3 inch or 0.105 to 3.33 mm diameter) in the spawning channel. For every 1 percent increase in sand a 1.26 percent decrease in survival-to-emergence occurred. In studies of coho salmon eggs, Tagart (1976) reported a negative correlation between survival-to-emergence and sediments less than 0.03 inch (0.83 mm) and a positive correlation between survival and sediment size of 0.13 to 1.06 inch (3.35 to 26.9 mm) particle diameter.

Channel material composition can also affect juvenile and adult fish. Investigations by Bjornn and others (1977) showed that fewer age 0 steelhead trout and chinook salmon overwintered in fully sedimented riffles than in unsedimented channels. The addition of sediments smaller than 0.25 inch (6.35 mm) particle diameter also led to reduced summer carrying capacity as intragravel crevices for juvenile fish were eliminated.

Fish can also be indirectly affected by sedimentation when a food source (aquatic insects) is damaged. Suspended sediment particles can wash insects off stream bottom material and downstream, thus decreasing their availability as food for fish. Also a significant relationship exists between decreasing substrate particle size and decreasing number of organisms, chiefly because of smothering (Scott 1966, Bjornn and Others 1977).

Debris and Nutrients Additions

Inputs of debris and nutrients are the result of improper logging on the stream riparian zone. Lack of buffer strips can result in debris damming the stream, fish migration blocks, debris torrents, decreased dissolved oxygen concentration, increased water temperature, increased nutrient inputs, and increased toxic leachates from decomposing material. The majority of these pollution problems can be eliminated with proper logging techniques.

Debris torrents are caused when debris jams break up and large quantities of water and material flow downstream. Such torrents may flood and scour the stream channel and topple vegetation on the streambanks, resulting in a "blow-out" of the stream and in long-term damage to streambank and channel stability.

The quality and quantity of nutrients in streams increase when the rate of decomposition exceeds the uptake by vegetation (Rothacher and Lopushinsky 1974). In addition, nutrients can be attached to eroded soil particles and organic particulate matter (Fredriksen 1972).

An indirect result of clearcutting can be a decrease in allochthonous organic detritus, terrestrial plant material entering the stream. This is a food source for aquatic invertebrates, that in turn are eaten by trout. Investigations showed that allochthonous leaf material was the most important food source for aquatic invertebrates in a small mountain stream (Minshall 1967). A shift in invertebrate species composition can occur with changes in organic detritus, temperature, and sedimentation. Such a shift may affect fish populations in the area, as they prefer feeding on one insect species over another. As revegetation follows clearcutting the invertebrate community restablishes itself.

Chemical Additions

Logging activities can also release manmade chemicals to the stream ecosystem. Herbicides, pesticides, and fire retardants can be directly or indirectly toxic to aquatic life. Some chemicals in channel sediment can be released into the aquatic system over a period of time.

Future Needs

The technology has been formulated to log areas with methods that minimize pollution impacts. Best management practices have been developed by government agencies, in cooperation with researchers and the logging industry. Up to this time, however, use of these practices by logging operators has been slight, with insufficient inspection and enforcement by land managers to guarantee compliance.

For example, present enforcement of logging practices in the State of Idaho is largely a matter of operator cooperation. Because of manpower limitations, inspections are made on the following priority basis: 1) complaints, 2) inquiries from the operator as to whether the operation meets standards, and 3) random sampling. In 1977, inspections were made by eight state employed foresters working part time on enforcement, with only 10 to 50 percent of the active logging operations inspected (State of Idaho Department of Lands figures).

On Federal lands (especially those administered by Forest Service), the planning process is designed to eliminate most compliance problems before they occur. The Forest Service uses a sale administrator to supervise on-site operations to insure compliance by the operator with the provisions of the contract. Requirements for certification as a sale administrator, which are rudimentary, include training in areas of timber administration, but virtually none in management of biological or ecological systems. This lack of training may be reflected in insufficient protection of water quality during logging operations. More stringent state and federal enforcement should be emphasized to guarantee on-site compliance with best management practices for logging.

Managers should use the management practices most appropriate to specific locations. Careful weighing of the costs and benefits of logging or not logging a site will be necessary (Larse 1970), and decisions will involve some compromises on all sides. Diversity in climate, geology, and biology of each proposed logging area makes site-specific planning a necessity since a standard set of "good rules" for logging is not realistic.

The Forest Service is attempting to use the site-specific method and teams of planning specialists. The site-specific method is an expensive, time-consuming process, but is the only valid way to evaluate individual areas for development. Emphasis on best management practices and site-specific planning is needed in the future.

LITERATURE CITED

Adams, S. N. 1975. Sheep and cattle grazing in forests: A Review. J. Appl. Ecol. 12(1):143-152.

Alderice, D. F., W. P. Wickett, and J. R. Brett. 1958. Some effects of temporary exposure to low dissolved oxygen levels on Pacific salmon eggs. J. Fish. Res. Board Can. 15:229-250.

Armour, C. L. 1977. Effects of deteriorated range streams on trout. Bur. Land Manage. Idaho State Off., Boise, 7p.

Aubertin, G. M., and J. H. Patric. 1974. Water quality after clearcutting a small watershed in West Virginia. J. Environ. Qual. 3(3):243-249.

Bjornn, T. C. 1969. Embryo survival and emergence studies. Job No. 5, Salmon Steelhead Invest., Proj. No. F-49-R-7. Annu. Completion Rep. Idaho Fish and Game Dept., 11 p.

Bjornn, T. C., M. A. Brusven, M. P. Molnau, J. M. Milligan, R. A. Klamt, E. Chacho, and C. Shaye. 1977. Transport of granitic sediment in streams and its effects on insects and fish. Univ. Idaho Forest, Wildlife and Range Exp. Stn., Bull. No. 17. [Moscow, Idaho, Sept. 1977] 43 p.

Brown, G. W., and J. T. Krygier. 1967. Changing water temperatures in small mountain streams. J. Soil and Water Conserv. 22:242-244.

Brown, G. W., and J. T. Krygier. 1970. Effects of clear-cutting on stream temperature. Water Resour. Res. 6(4):1133-1140.

Brown, G. W., and J. T. Krygier. 1971. Clear-cut logging and sediment production in the Oregon coast range. Water Resour. Res. 7(5):1189-1198.

Churchill, M. A., R. A. Buckingham, and H. L. Elmore. 1962. The prediction of stream aeration rates. TVA Div. Health and Safety, Chattanooga, Tenn., 98 p.

Claire, E., and R. Storch. (In Press). Streamside management and livestock grazing: An objective look at the situation. In Livestock interactions with wildlife, fish and their environments symposium. John Menke (ed). [Sparks, Nevada, May 1977]. USDA For. Serv., Pac. Southwest For. and Range Exp. Stn., Berkeley, Calif.

Coble, D. W. 1961. Influence of water exchange and dissolved oxygen in redds on survival of steelhead trout embryos. Trans. Am. Fish Soc. 91:469-474.

Douglass, J. E., and W. T. Swank. 1975. Effects of management practices on water quality and quantity - Coweeta Hydrologic Laboratory. p. 1-3. In Munic. watershed manage.: symposium proceedings USDA For. Serv. Gen. Tech. Rep. NE-13. Northeastern For. Exp. Stn., Broomall, Pa.

Duff, Don A. (In Press). Livestock grazing impacts on aquatic habitat in Big Creek, Utah. In Livestock interactions with wildlife, fisheries and their environments symposium. John Menke (ed). [Sparks, Nevada, May 1977] USDA For. Serv., Pac. Southwest For. and Range Exp. Stn., Berkeley, Calif.

Eddy, R. M. 1972. The influence of dissolved oxygen concentration and temperature on the survival and growth of chinook salmon embryos and fry. M.S. Thesis, Oregon State Univ., 45 p.

Eschner, A. R., and J. Larmoyeux. 1963. Logging and trout: four experimental forest practices and their effect on water quality. Prog. Fish Cult. 25:59-67.

Fredriksen, R. L. 1972. Nutrient budget of a Douglas-fir forest on an experimental watershed in western Oregon. p. 115-131. In Research on coniferous forest ecosy stems - a symposium. USDA For. Serv. Pac. Northwest For. and Range Exp. Stn., Portland, Ore.

Gangmark, H. A., and R. D. Broad. 1955. Experimental hatching of king salmon in Mill Creek, a tributary of the Sacramento River, Calif. Calif. Fish and Game 41:233-242.

Gifford, Gerald. 1975. Beneficial and detrimental effects of range improvement practices on runoff and erosion. Watershed Manage. Symp. [Logan, Utah, Aug. 11-13, 1975] p. 216-274.

Green, G. E. 1950. Land use and trout streams. J. Soil and Water Conserv. 5:125-126.

Gunderson, Donald R. 1968. Floodplain use related to stream morphology and fish populations. J. Wildl. Manage. 32(3):507-514.

Hall, J. D., and H. J. Campbell. 1968. The effects of logging on the habitat of coho salmon and cutthrout trout in coastal streams. p. 5-28. In The relation between logging and salmon: proceedings on forum. American Inst. of Fishery Research Biologists Alaska Dist. [Juneau, Alaska, Feb. 1968].

Hall, J. E., and R. L. Lantz. 1969. Effects of logging on the habitat of coho salmon and cutthroat trout in coastal streams. p. 355-375. In T. G. Northcote (ed), Salmon and trout in streams: proceedings of symposium. Univ. British Columbia, Vancouver.

Harrison, C. W. 1923. Planting eyed salmon and trout eggs. Trans. Am. Fish Soc. 53:191-200.

Hayes, Frank. 1978. Streambank stability and meadow condition in relation to livestock grazing in mountain meadows of central Idaho. M.S. Thesis, Univ. Idaho, Moscow, 91 p.

Heady, H., Thadis W. Box, John E. Butcher, and others. 1974. Livestock grazing on Federal lands in eleven western states. J. Range Manage. 27(3):174-181.

Herrmann, R. B., C. E. Warren, and P. Doudoroff. 1962. Influence of oxygen concentration on the growth of juvenile coho salmon. Trans. Am. Fish. Soc. 91:155-167.

Hoopes, R. L. 1975. Flooding, as the result of Hurrican Agnes, and its effect on a macrobenthic community in an infertile headwater stream in central Pennsylvania. Limnol. and Oceanogr. 19:853-857.

Hormay, A. L. 1970. Principles of rest-rotation grazing and multiple use land management. Training text 4(2200). USDA For. Serv., Wash., D.C.

Hornbeck, J. W. 1967. Clear-cutting and the erosion hazard. Northern Logger and Timber Proc. 16(4):14-15, 38-39, 43.

Hornbeck, J. W. 1968. Protecting water quality during and after clear-cutting. Soil and Water Conserv. 23(1):19-20.

Hornbeck, J. W., and C. A. Federer. 1975. Effect of management practices on water quality and quantity, Hubbard Brook Exp. For., New Hampshire. p. 48-65 In Municipal watershed management symposium. USDA For. Serv. Gen. Tech. Rep. NE-13 Northeastern For. Exp. Stn., Broomall, Pa.

Kennedy, C. 1977. Wildlife conflicts in riparian management: Water. p. 52-58. In Importance, preservation and management of riparian habitat symposium. USDA For. Serv., Gen. Tech. Rep. RM-43. Rocky Mt. For. and Range Exp. Stn., Ft. Collins, Colo.

Kochenderfer, J. N., and G. M. Aubertin. 1975. Effect of management practices on water quality and quantity - Ferrow Exp. For. West Virginia. p. 14-24. In Municipal watershed management: proceedings of symposium. USDA For. Serv., Gen. Tech. Rep. NE-13. Northeastern For. Exp. Stn., Broomall, Pa.

Koski, K. V. 1975. The survival and fitness of two stocks of chum salmon (Oncorhynchus keta) from egg deposition to emergence in a controlled stream environment in Big Beef Creek. Ph.D. Diss. Univ. Wash., Seattle, 212 p.

Lantz, R. L. 1971. Guidelines for stream protection in logging operations. Oreg. State Game Comm. Rep. Res. Div., Portland, 29 p.

Larse, R. W. 1970. Prevention and control of erosion and stream sedimentation from forest roads. p. 76-83, In Forest land uses and stream envion.: symposium proceedings [Oct. 19-21, 1970]. Oregon State Univ.

Leopold, A. Starker. 1974. Ecosystem deterioration under multiple use. In Wild trout manage.: symposium proceedings. p. 96-98. USDI Fish and Wildl. Serv. and Trout Unlimited, Denver, Colo.

Lieberman, J., and M. D. Hoover. 1948. The effect of uncontrolled logging on stream turbidity. Water and Sewage Works. 95(7):255-258.

Likens, G. E., F. H. Bormann, M. M. Johnson, D. W. Fisher, and R. S. Pierce. 1970. Effects of forest cutting and herbicide treatment on nutrient budget in the Hubbard Rock watershed ecosystem. Ecol. Monogr. 40(1)23-47.

Lorz, H. W. 1974. Ecology and management of brown trout in Little Duschutes River. Fish. Res. Rep. 8. 49 p. Oreg. Dept. Fish and Wildl., Portland Ore.

Lull, H. W., and K. G. Reinhart. 1967. Increasing water yield in the Northeast by management of forested watersheds. USDA For. Serv. Res. Pap. NE-66, 45 p. Northeastern For. Exp. Stn., Broomall, Pa.

Lynch, J. A., W. E. Sopper, and D. B. Partridge. 1972. Changes in streamflow following partial clear-cutting on a forested watershed. p. 313-320: In Watersheds in transition: National symposium proceedings Colo. Am. Water Res. Assn. and Colo. State Univ., Ft Collins, Colo.

Lynch, J. A., W. E. Sopper, E. S. Corbett, and D. Aurand. 1975. Effects of management practices on water quality and quantity - Penn State Exp. watersheds. p. 32-46. In Municipal watershed management: symposium proceedings, USDA For. Serv. Gen. Tech. Rep. NE-13. Northeastern For. Exp. Stn., Broomall. Pa.

Lynch, J. A., E. S. Corbett, and R. Hoopes. 1977. Implications of forest management practices on the aquatic environment. Fisheries 2(2):16-22.

Marcuson, Patrick E. 1977. The effect of cattle grazing on brown trout in Rock Creek, Montana. Proj. No. F-20-R-21-11-a. 26 p. Mont. Dept. Fish and Game, Helena.

Mason, J. C. 1969. Hypoxial stress prior to emergence and competition among coho salmon fry. J. Fish Res. Board Can. 26:63-91.

McGowan, Terry. 1976. Statement on improving fish and wildlife benefits in range management. In Improving fish and wildlife benefits in range manage.: Proceedings of a seminar [Washington, D.C., March 1976] p. 97-102. USDI Fish and Wildl. Serv., Biol. Serv. Program, Wash., D.C.

McNeil, W. J., and W. H. Ahnell. 1964. Success of pink salmon spawning relative to size of spawning bed materials. USDI Fish and Wildl. Serv. Spec. Sci. Rep. Fish. No. 405, 15 p. Wash., D.C.

Meehan, William R., and William S. Platts. 1978. Livestock grazing and the aquatic environment. J. Soil and Water Conserv. 33(b):274-278.

Megahan, W. F., and W. J. Kidd. 1972. Effect of logging and logging roads on erosion and sediment production from sheep terrain. J. For. 70(3):136-141.

Meiners, William R. 1974. Rest Rotation Grazing - A Bummer. Presented to Society for Range Management. 27th Annu. Meeting, Tucson, Ariz.

Menke, John (ed). (In Press). Symposium on livestock interaction with wildlife, fisheries and their environments, [Sparks, Nevada, May 1977] USDA For. Serv., Pacific Southwest For. and Range Exp. Stn., Berkeley, Calif.

Minshall, G. W. 1967. The role of allochthonous detritus in the trophic structure of a woodland spring brook community. Ecology 48(1):139-149.

Packer, P. E. 1957. Management of forest watersheds and improvements of fish habitat. Trans. Am. Fish. Soc. 87(4):392-397.

Packer, P. E., and B. D. Williams. 1974. Logging and prescribed burning effects on the hydrologic and soil stability behavior of larch-Douglas fir forests in the northern Rocky Mountains. p. 465-479. In Montana tall timbers fire ecology conference and fire and land management: symposium proceedings No. 14.

Patric, J. H. 1973. Deforestation effects on soil moisture, streamflow and water balance in the central Appalachians. USDA For. Serv. Res. Pap. NE-259. Northeastern For. Exp. Stn., Upper Darby, Pa.

Pearce, K. G., and G. Stenzel. 1972. Logging and pulpwood production. The Ronald Press Co., New York.

Pearson, W. S., and D. R. Franklin. 1968. Some factors affecting drift rates of Baetis and Simuliidae in a large river. Ecology 49:75-81.

Phillips, R. W., H. J. Campbell, W. L. Hug, and E. W. Claire. 1966. A study of the effect of logging on aquatic resources 1960-1966. Ore. State Game Comm. Res. Div. Prog. Memo. Fish. Ore. State Univ. Corvallis, 28 p.

Platts, William S. 1970. The Effects of logging and road construction on the aquatic habitat of the South Fork Salmon River, Idaho. USDA For. Serv. Zone Fish. Biol. 4 p.

Platts, William S. 1978a. Livestock interaction with fish and aquatic environments: problems in evaluation. 43rd North Am. and Natl. Resour. Conf., Wildl. Manage. Inst., Wash., D.C., p. 498-504.

Platts, William S. 1978b. The effects of livestock grazing in high mountain meadows on aquatic environments, streamside environments, and fisheries - A study plan. USDA For. Serv., Int. For. and Range Exp. Stn., Ogden, Utah. 99 p.

Ponce, S. L. 1974. The biochemical oxygen demand of finely divided logging debris in stream water. Water Resour. Res. 10(5):983-988.

Reinhart, K. G., and A. R. Eschner. 1962. Effect on streamflow of four different forest practices in the Alleghany Mountains. J. Geophys. Res. 67(6):2433-2445.

Ringler, N. H., and J. D. Hall. 1975. Effects of logging on water temperature and dissolved oxygen in spawning beds. Trans. Am. Fish. Soc. 1:111-121.

Rothacher, J., and W. Lopushinsky. 1974. Soil stability and water yield and quality. p. D1-D22. In Environmental effects of forest residues management in the Pacific Northwest. USDA For. Serv., Gen. Tech. Rep. PNW-24. Pac. Northwest For. Range Exp. Stn., Portland, Ore.

Scott, D. 1966. The substrate cover-fraction concept. In Cummins et al. (ed) Organism substrate relationships in streams. Sp. Publ. 4. Pymatuning Lab. Ecol. Univ. Pittsburgh.

Shapovalov, L. 1937. Experiments in hatching steelhead eggs in gravel. Calif. Fish and Game 23(3):208-214.

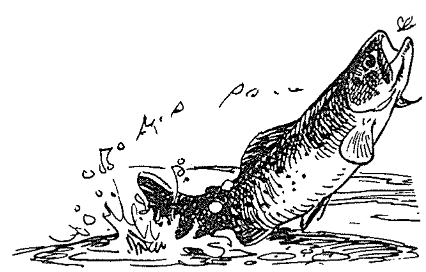
Tagart, J. V. 1976. The survival from egg deposition to emergence of coho salmon in the Clearwater River, Jefferson County, Washington. M.S. Thesis. Univ. Wash. Seattle, 101 p.

Townsend, Joseph E., and Robert J. Smith, eds. 1977. In Improving fish and wildlife benefits in range management: proceedings of a seminar. [Washington, D.C., March 1976] 118 p. USDI Fish and Wildl. Serv., Biol. Serv. Program, Wash., D.C.

Trimble, G. R., and S. Weitzman. 1953. Soil erosion on logging roads. Soil Sci. Soc. Am. Proc. 17:152-154.

U.S. Senate. 1936. The western range. Letter from the Secretary of Agriculture, 74th Congress, 2nd Session, Senate Doc. No. 199, 620 p.

Wells, R. A., and W. J. McNeil. 1970. Effect of quality of the spawning bed on growth and development of pink salmon embryos and alevins. U.S. Fish Wildl. Serv. Spec. Sci. Rep. Fish No. 616, 6p.



TROUT HABITAT --- A THREE-SIDED APPROACH

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Abstract.--Trout habitat management is wild trout management. Trout habitat management: protection, maintenance, and improvement is inseparable from wild trout management. Many well-intentioned organizations and agencies, devote an inordinate amount of effort to developing regulations designed to reduce the harvest of wild trout -- while the more complex issues of trout habitat management are often neglected.

Wild trout management is addressed in three habitat issues. Habitat as a legislative issue describes the efforts, frustrations, and possible actions when attempting to enact legislation designed to prevent the unnecessary destruction of trout streams by dewatering and channelization.

Habitat as a basis for a wild trout management policy describes a strategic plan employed by the Wyoming Game and Fish Department. The plan delineates five concepts, premised on the ability of specific aquatic environments to sustain a trout population.

The third issue: habitat field actions, describes Wyoming's program of restoring and improving trout habitat. A description of construction activities to maintain, protect, and enhance wild trout populations is enumerated on a drainage by drainage basis.

SIDE I -- HABITAT, A LEGISLATIVE ISSUE

"At this time we are opposed to the protection of stream channel proposals and any proposal attempting to regulate stream channel changes that would interfere with agriculture practices or prevent the beneficial use of Wyoming water by Wyoming citizens."

That policy was adopted by the delegate body of the Wyoming Farm Bureau at their 1974 annual meeting in Jackson. This policy was originally part of a more extensive statement which included opposition to state river protection legislation.

Since the 1975 Legislative Session, bills have been introduced that would have established a river protection system, providing for special measures to maintain all aspects of designated running water habitats. This proposal would have included all of Wyoming's blue ribbon trout waters along with a number of streams managed specifically for wild trout populations. A separate law would have provided for the protection of stream channels.

The Farm Bureau was successful in opposing both of these actions in Committee. This happened in spite of the fact that this legislation resulted from a two-year interim study authorized by the Wyoming Legislature in 1973. Again in 1977 the proponents for the river protection system and the protection of stream channels introduced bills. Although amendments suggested by the Farm Bureau were adopted, this legislation was also defeated in Committee.

No river protection legislation was prefiled in the 1979 Legislative Session. However, various environmental and sportsmen's groups again persisted, and, at the final hour, a stream channel protection bill was introduced. The final bill, Senate File No. 183A, incorporated many of the suggested changes previously recommended by the Farm Bureau and was successful in winning Senate approval. A "do-not-pass" recommendation from the House Agricultural Committee prevented the bill from receiving full House consideration. The Farm Bureau did not initially testify against the Senate passed version, but remained neutral since most of the objectional features of the original bill had been removed. Apparently, the "do-not-pass" recommendation resulted from some second thoughts on the bill, and it was defeated on the basis that the penalty provisions were too punitive. The Farm Bureau did not, however, suggest amendments that would have reduced penalties. It is interesting to note that this legislation would have meant that an individual who violated this proposed law would have been guilty of a misdemeanor and, if convicted, could have been punished by a fine of not more than $500 for each day of violation.

At its February 7, 1979, meeting the Wyoming Farm Bureau's Natural Resource and Environmental Committee decided that the organization needed to re-examine its stand on its present policy on stream protection legislation. On May 30th of this year, Don Dexter, Assistant Director of the Wyoming Game and Fish Department, made a presentation to committee members explaining the need for state legislation to protect stream channels. He indicated that prior to 1965 the deterioration of trout streams in Wyoming was minimal. Since that time and until the end of 1977, his report indicated that 31 miles of prime trout streams have been lost due to channel change activities. It was noted that as Wyoming's population grows and the state becomes more industrialized the acceleration of habitat deterioration of top trout streams will increase.

At the present time the Farm Bureau is reexamining its position on opposing any legislation to place any controls on stream channel changes. They have a number of alternatives: they can retain their present policy, they can support protection of stream channel legislation if it provides certain features, they could neither oppose or support stream channel protection legislation, or they could take the position that if such legislation is enacted certain specifications must be met or the Farm Bureau would be again obliged to oppose such a measure. Many Farm Bureau leaders felt that the 1979 legislation was much more acceptable, especially if the $500 per day were eliminated or reduced.

This, then presents a very brief scenario of how a rather simple issue of requiring a permit before legalizing the destruction of trout habitat can be delayed year after year. This has gone on while fishermen continue to disregard the fact that the main problem of maintaining trout populations lies with the protection of habitat through legislative action. Instead fishermen, through their friends in the State Legislature, continue to support the somewhat lesser issue of special licenses for Colorado fishermen and a number of other rather easy policing actions for the Game and Fish Department. A total commitment to this reasoning disregards the fact that the back of the house is burning while the owners are trying to decide the color to paint the front of the house.

Prior to 1974 there were some feeble attempts made to introduce legislation which would have perhaps slowed the deterioration of trout habitat. During that period, however, sportsmen's groups were more interested in tackle restrictions, creel limits, and especially in Wyoming, concerns for issues associated with big game rather than for those associated with trout fishing. As a result, in the years following World War II the number of trout streams supporting trout populations were severely depreciated. It is interesting to note that the legislative action which created the Interim Committee to study the need for river and stream protection was a product of the League of Women Voters. The initial support from sportsmen's groups, fly fishing groups, etc. was minimal.

In Wyoming we have reached the eleventh hour. Industrialization and rapidly growing urban areas are competing with agriculture and wildlife for the last of those habitats not yet protected. There is, however, a growing awareness by the trout fishing public and many other organizations interested in the protection of fluvial habitats that they can have a decided effect on the legislative process. It is also encouraging to note that the Farm Bureau will perhaps change its position on the protection of stream and river habitat. Perhaps the most encouraging development is the trout fishing public, along with many other Wyoming citizens sensitive to beauty and value of undisturbed streams. These groups are beginning to organize as a viable force for legislative action on this issue. I should also mention that opponents of legislation of river and stream protection at the state level are beginning to recognize that if control of this matter is to be left with local authority, state recognition of this is paramount. The U. S. Fish and Wildlife Service Instream Group in Fort Collins and the U. S. Army Corps of Engineers 404 Permit requirements prior to stream channel manipulation has not gone unnoticed. Previous opponents of river protection legislation, I believe, now realize that it is time for recognition of this issue by enacting appropriate state laws.

I must admit, however, that over the years my disillusionment has grown over the process of state legislation, on issues of environmental concern. Significant action often comes only as a result of legislation or a threat of legislation at the Congressional level.

Joseph Congleton's paper, "Amnesty for your River--Basic Considerations", presented at the Wild Trout Management Symposium five years ago at this same location, is an excellent reference on how to address this issue. To paraphase from Mr. Congleton's paper:

- Apply pressure where it will count and see the right people first. "If you expect to achieve results you have to make some political investments."
- If you are going to effectually lobby for legislative action for trout habitat protection you must initiate the campaign at an early stage.
- Communication is the most serious obstacle to a successful lobby effort to protect natural resources. Build a coalition of interested groups and fully communicate and coordinate these efforts well in advance of the convening of the legislation.

SIDE II -- HABITAT, THE BASIS FOR POLICY

In 1975 the Wyoming Game and Fish Department released its first comprehensive strategic plan for the management of wildlife in Wyoming. The strategic plan for sport fisheries management is essentially contingent on the ability of specific aquatic habitats to sustain a species-specific game fish population through natural reproduction or through stocking programs where reproduction is lacking or inadequate.

All of Wyoming's waters are currently managed under one of five management concepts. These are basic yield, put-and-take, trophy, unique species, and wild. Basic yield waters are those waters which have the ability to grow and maintain game fish, but require stocking because of inadequacies in the environment. Most of Wyoming's large reservoirs are managed under basic yield concept. The put-and-take concept of fisheries management is directed toward creating fishing opportunity where little opportunity would normally exist because of depreciated habitat conditions and where waters are not capable of growing fish to meet local fishing pressure. The unique species concept is in fact a wild trout management concept. This concept applies to waters where management is primarily directed toward maintaining a sport fisheries supported by a particular species or sub-species. Fish that are considered under this concept include subspecies of cutthroat trout in their native habitat, grayling, golden trout, and in fact, any species with some unique characteristic worth perpetuating. Again, the baseline for waters to be considered with a unique species concept of management requires habitat that is essentially intact and contains all the elements for a species to complete its life cycle. The trophy concept applies to water where management is primarily directed toward providing the fisherman with the opportunity to catch a larger than average fish. These waters include those habitats which produce wild trout or habitat that does not have all the necessary elements for a species to complete its life cycle.

The wild concept of fisheries management applies to all waters where management is primarily directed toward providing the fisherman with the opportunity to catch a fish from a fishery totally supported by natural reproduction. Again, the bottom line in this concept requires undisturbed habitat or habitat not seriously depreciated by man. I should note that this concept does not restrict initial stocking or stocking for the reestablishment of a fishery following some unforeseen catastrophe. Waters managed under the wild concept must meet the following criteria: high potential for game fish reproduction, and a denisty of game fish capable of sustaining a fishery without stocking, or with regulations to produce a harvest in balance with the productive capacity of the habitat. Again, these two points are contingent on the maintenance and protection of habitat. The wild fish concept of management in Wyoming is limited to the following species: rainbow, cutthroat, brown, golden, brook, and mackinaw trout, and grayling and whitefish. With the exception of perhaps mackinaw trout, all of these species require fluvial habitat.

To understand how rapidly life styles are changing in Wyoming, it is important to give you some idea what fishing pressure is like in our state. In 1978 it was estimated that fishing pressure was about 3,297,000 fisherman days. It has been further estimated that of this total, about 1,900,000 fisherman days were spent on mountain creeks, rivers, streams, and beaver ponds. All of these habitats are highly vulnerable to water development activities required to sustain the state's industrial and agricultural communities. The potential for a conflict on this issue lies with the fact that the Wyoming Game and Fish Department's management framework requires the protection and maintenance of at least 372 miles of stream habitat classified as "national interest" water. Also, the Wyoming Game and Fish Department is required to protect and maintain at least 1,200 miles of stream habitat classified as "regional interest" water.

In the 1978 Strategic Plan the following notation is made: "For the next 15 years a decrease in total stream miles will correspond with new water development and increase water demands for municipal, industrial, and agricultural use. However, total stream fishing supply does not have to be reduced if water development projects include adequate downstream flows for enhancement of fisheries; if minimum stream flows can be obtained where presently lacking; if legislation is enacted recognizing fish, wildlife, and recreation as beneficial uses of water and prohibiting unauthorized alteration of stream channels." In the summary it is projected that state-wide fishing supply will remain fairly stable over the next 15 years, IF proper considerations are given to fisheries habitat and land use practices. Conversely, without these considerations, sport fishing supply will be seriously reduced.

At the present there appears to be a philosophy among many of the State's leaders that additional concessions will have to be made by those supportive of the protection of aquatic environments. This philosophy, if continued in Wyoming, supports the premise that trout habitat will be unavoidably reduced. I personally feel that this is axiomatic, only if the trout fishermen, the fishery biologists, and the concerned citizens allow it to happen.

To underscore this point, let me quickly enumerate Wyoming's state-wide problems as they are presented in the Wyoming Game and Fish Department's publication entitled, "A Strategic Plan for the Comprehensive Management of Wildlife in Wyoming, 1978 to 1983". The overall number one state-wide problem is destruction and alteration of aquatic habitats. Strategies enumerate: negotiate for minimum flows in all waters of significant fisheries potential, enact legislation requiring adequate minimum stream flows, enact legislation requiring approval from the State Engineer or other authority before a stream channel can be altered, enact state-wide regulations designed to protect stream channels, and enact legislation requiring compensation or mitigation for all projects which detrimentally alter aquatic habitat. On a regional basis problems were ranked as follows: In the Snake River drainage the number one problem was listed as stream channelization and diking seriously affecting fisheries habitat on the Snake River and several other streams. Problem number two is noted as: several streams in this area and especially the Gros Ventre are partially or totally dewatered during part of the year. In the Wind, Big Horn, Yellowstone, and Clarks Fork River drainages the number one problem was listed as, channelization and dewatering. The number two problem: irrigation projects cause heavy siltation in many of the waters of the region. In the Powder, Tongue, Little Missouri, Belle Fourche, Cheyenne, and Niobrara River drainages the number one problem was listed as, increases in fishing pressure will cause sport fishing demand to exceed supply in the near future. Two of the strategies to help solve this problem are listed as, minimum stream flows to enhance existing fisheries and to negotiate minimum stream flows on new water projects. In the Green, Bear, and Little Snake River drainages, the number one problem was: much of the stream fishing opportunity in this region is limited by habitat improvement efforts especially in those areas where stream fishing opportunity is limited. In the North and South Platte River drainages the number two problem was, the North Platte River from the mouth of Sage Creek to Seminoe Reservoir, LaPrelle Creek and several other important streams have reduced fisheries potential due to siltation problems. (The number one problem was, fishing pressure.)

The importance of habitat in Wyoming's Strategic Plan is recognized. The over-riding issue is the need for legislation to provide for the protection of wild trout habitat. The unanswered question is, "Will the fisherman recognize the strength of his vote in bringing about the necessary reforms?" I think the answer is, "Yes".

SIDE III -- HABITAT, FIELD ACTION

Although there has been no really significant progress in the struggle with legislators to preserve aquatic habitat in Wyoming, there has been an inspirational movement by the State Game and Fish Department in the restoration and improvement of trout habitat.

This has resulted in some rather interesting and rewarding results, insofar as wild trout are concerned.

This is the "Show and Tell" point of my presentation and the portion of the presentation which I am privileged to make on behalf of the many Wyoming Game and Fish Department personnel who have been involved in this program.

Before I go on to a description of the work that is being done, it is important for me to mention that wild trout habitat management in Wyoming also has an important linkage with the fish cultural program. In an effort to reintroduce certain trout species or sub-species to habitat where they have long been absent and to introduce certain wild trout varieties to habitat that has been restored or where habitat has been without trout because of physical barriers, brood stock of a number of varieties of cutthroat have been established. Taking eggs directly from wild trout stock has enabled fisheries managers to take significant steps in maintaining and enhancing indigenous populations of cutthroat. Bear River cutthroat eggs have been obtained from native fish found in Raymond Creek. From these eggs it is anticipated that the range of this fish, which was thought to be extinct by some investigators a few short years ago, can be reestablished as an important species in the sport fishing program. In addition, in order to maintain the historical distribution of cutthroat varieties, brood stocks of Yellowstone cutthroat, Colorado cutthroat, and Snake River cutthroat have been established.

An interesting sidelight to these activities is a program initiated in 1977 by the Wyoming Game and Fish Department to introduce a lotic variety of Yellowstone cutthroat to the Thoroughfare and Yellowstone drainages, devoid of fish because of physical barriers downstream. A variety of "stream dwelling" Yellowstone River cutthroat has been selected from Sedge Creek. These cutthroat trout have been isolated from Yellowstone Lake cutthroat by natural thermal conditions. It appears as though transplants of this variety into the headwaters of the Yellowstone River have been successful.

In an effort to improve populations of Snake River cutthroat in the Snake River downstream from Jackson Lake dam to the backwaters of Palisades Reservoir, a biological survey of this drainage was initiated 30 years ago. Follow-up surveys established that a deterioration of spawning habitat had occurred as a result of flood control measures taken by the Corps of Army Engineers in the late 50's and 60's. The development of new, and the improvement of old, spawning channels in spring seep areas resulted in a nine-fold recruitment of young-of-the-year trout. In 1978, at the Bar B C Spring Creek monitoring trap, Snake River cutthroat numbers were the largest ever recorded. The increase in spawners was attributed to the development of spawning gravels, to the protection of spawning habitat, and to eyed-egg plants made in the early 1970's.

As a result of the deterioration of Snake River habitat between the flood control levees, a rather unique project has evolved. To provide gravel for the construction of highways and general construction work in the Jackson, Wyoming, area, without further damaging, and in fact improving, trout habitat in the main channel, gravel removal operations are encouraged. The removal of an estimated 300,000 cubic yards of gravel is monitored by infrared aerial photography. Changes in the physical features of the river with special reference to trout habitat will be interpretted by specialists at Colorado State University. Although it is premature to comment on the results of this program, it appears as though this might be a good example of how gravel removal, usually a damaging practice, might be used to good advantage for trout habitat improvement.

On the Salt River, a major tributary to the Snake River, stream bank willow removal programs, stream bank damage by livestock, and "do-it-yourself flood control" projects have eliminated many miles of critical trout habitat. Since the late 1960's the Wyoming Game and Fish Department has been engaged in a "critical-area-habitat" treatment project associated with public fishermen easements. In 1976 and 1977 this program was accelerated by a cooperative agreement with the SCS using RC and D funds. First phase of this work requires a total of 9,510 feet of stream bank treatment including tree reventments, supplemental rock fill, grazing barrier trees, and fencing. In 1978 and 1979, 8,600 linear feet of tree reventments, 350 cubic yards of rock, 875 cubic yards of gravel, and 1,330 linear feet of fence, plus 86 grazing barrier trees have been or will be installed.

So far I have discussed only wild trout habitat improvement programs in the Snake River drainage. Similar habitat improvement programs have been or will be initiated in the other fisheries management districts in Wyoming. Time does not permit me to review all these projects. I will, however, note that habitat improvement and restoration work is in progress on the Green River and the Little Popo Agie. Instream boulder retards, stream bank rip rap, offset diking, boulder clusters, and log cribs have been installed with good results. All projects are being evaluated on the basis of changes in trout numbers, age groups, species composition, and condition of the trout populations previous to and following installation of the structures. Trout habitat improvement on Beaver Creek, a small trout stream in Wyoming's Black Hills, has resulted in wild populations of brook trout maintained by natural recruitment in areas previously dependent on annual stocking.

Inseparable from the issue of trout habitat is the Habitat Quality Evaluation System developed by the Wyoming Game and Fish Department. I know that many of you present in the audience today have had the opportunity of hearing Dr. Allen Binns' presentation of the HQI System either at the American Fisheries Society meeting at Dearborn, Michigan, or at numerous other fisheries meetings in the intermountain region. You may have also read a description of the evaluation system in Vol. 108, No. 3 of the Transaction of the American Fisheries Society. I will not go into detail on the use of this system. It is important, however, that I note just one key practical way in which the HQI method has been used. The North Fork of the Little Snake River will be impacted by a proposed transmountain water diversion designed to provide additional water for the City of Cheyenne. Using the HQI method, fisheries personnel of the Wyoming Game and Fish Department were able to demonstrate to Cheyenne City planners, engineers, and the U. S. Forest Service a predicted cutthroat trout biomass loss of from 50 to 80 percent following construction, with no instream flow consideration. As a result, specific instream flows in this drainage will be included in a Forest Service Special Use Permit for the project. The HQI method has also been used to evaluate the difference between unaltered stream sections and those that have been altered by channelization projects.

This briefly describes Wyoming's efforts to protect, maintain, and to improve the status of its wild trout populations. It is a total effort involving close coordination from administrators, fisheries managers, fisheries researchers, fish culturists, and fisheries habitat specialists. In addition, the monumental job of coordination on an intra-, as well as inter-, departmental and federal agency level appears to have consistency and direction on habitat protection. This, plus an increasing awareness on the part of the public over the loss of trout habitat, makes me feel that the future of wild trout is brighter than it has been at anytime during the past decade.

TROUT MANAGEMENT IN COLORADO[1]

Eddie Kochman[2]

Abstract.--A description of Colorado's wild trout program including provisions for future management. Emphasis toward the importance of stream improvement in maintaining aquatic habitat for wild trout populations. A flexible hatchery system is required for the management of both wild trout and catchable trout programs. Colorado's future objective is to develop a diverse fishery program.

Let me discuss with you some of the specific programs that Colorado is undertaking regarding the management of coldwater fish species and particularly wild trout.

In 1976, the Division established its first catch and release or "no kill" area on three miles of the South Platte River. The area is one hour driving time from Denver and supports a fishery that is one of the finest in Colorado. The South Platte River is approximately 60 feet in width, has good water quality and habitat conditions and contains a wild trout population composed predominently of brown and rainbow trout. An estimate of existing numbers of hours spent by fishermen per mile ranges from 12,000 to 13,000. This is some of the highest use in Colorado and calculates out over 2,500 fishermen per mile of stream annually. No official evaluation was undertaken when the area was first established as a catch and release area in 1976, but based on fishermen use and catch data, the regulation has been a success.

In 1978, the Division of Wildlife established four additional streams under catch and release areas. Each of the waters supports populations of wild trout and one of the streams, the Lake Fork of the Conejos, has an excellent population of Rio Grande cutthroat which is considered a threatened fish species in Colorado. Regarding the population of Rio Grande cutthroat it is hoped that the catch and release regulation will allow fishing opportunity with little impact upon the population. The other alternative would have been complete closure for fishing on the Lake Fork of the Conejos since unrestricted fishing pressure would have been too great for maintenance of the cutthroat population.

To fully evaluate the impact of catch and release fishing, a full-time research project has been established. The research will be under the direction of Barry Nehring, a fish researcher with the Division. The project is designed over a three-year period and will include the objectives of determining changes in fish populations including the development of trophy fish, 14 inches and above, as well as hooking mortality. In addition, Barry will concentrate on obtaining an attitude or opinion survey of fishermen concerning catch and release. One very unique aspect of the research exists in that both individual fishermen as well as Trout Unlimited and the Federation of Fly Fishermen have been asked to cooperate in obtaining research and creel census data. To do this, an official "fishermen diary" was prepared and distributed to individual fishermen who indicated an interest in the program or who regularly fished the catch and release waters. Each fisherman is requested to fill out a diary with pertinent data. Individual fishermen were also requested to tag all fish caught 14 inches and above in total length. A training class was given to fishermen prior to the tagging operation. In addition to obtaining worthwhile information, this cooperative effort has established much goodwill with individual fishermen and organized groups.

Let me now give you a list of the criteria which should be considered before catch and release regulations are established.

[1]Paper presented at the Wild Trout II Symposium, Yellowstone National Park, Wyoming, September 24-25, 1979.

[2]Fish Program Manager, Colorado Division of Wildlife, Denver, Colorado.

1. Self-sustaining population of wild trout which has the biological potential to produce optimum numbers of large trout 14 inches or greater in length.
2. Existing fisherman pressure of at least 300 fishermen days/acre/season, which has been shown to overharvest wild trout populations. (Fisherman day = 4.2 hours)
3. A minimum length of two miles which has defined upper and lower points and is accessible.
4. Capability of sustaining a target catch per fisherman day of 4.0 with the establishment of a catch and release regulation.
5. Allow maintenance of wild trout population numbers with no artificial stocking.
6. Existance of threatened and endangered species which are especially vulnerable to angling pressure and over-harvest (will justify catch and release management with no other criteria).

In the future it is the objective of the Division of Wildlife to develop specific regulations that will be designed to enhance fishing opportunity while maintaining populations of wild trout. In some areas this may mean catch and release, in others it may mean a reduced bag limit or selective size limits on certain species. Prior to development of such regulation, it will be necessary to have the support of fishermen themselves.

In addition to the establishment of specific regulations, there are other areas that are of equal importance in the maintenance of wild trout populations. Perhaps one of the most neglected areas is the area of aquatic habitat or stream improvement. In the past, stream improvement projects have not always been considered beneficial. This was primarily due to poor design and projects which proved to be costly and ineffective. Within Colorado we have found that stream improvement can be very effective in enhancing spawning, resting and feeding habitat for populations of wild trout. One good example was the recent Tenmile Creek Project where over three miles of stream were relocated by the Colorado Division of Highways for the purpose of constructing a major four-lane highway. The relocated stream was designed in such a manner so as to actually enhance aquatic habitat. The completed project is today actual testimony to the fact that stream improvement can be beneficial. The Division of Wildlife itself now has budget money solely for the purpose of enhancing aquatic habitats in selected streams. During Fiscal Year 1979-80, a total of $120,000 will be spent for this purpose. The priority is spending these monies on streams that support wild trout but have limited populations due to poor spawning, feeding and resting habitat. The following criteria are used by the Division in determining whether or not to implement stream improvement:

1. Pool riffle ratio in excess of 30:70. A pool riffle ratio of 50:50 is considered optimum by many biologists. A stream with 70 percent riffle will likely not have required shelter or resting areas for trout.
2. Average annual discharge less than 300 c.f.s. Small streams with low discharges offer the greatest opportunity to effectively undertake stream improvement. Larger streams that have an excess of 300 c.f.s. (average daily flow) do have potential for improved habitat conditions by the placement of large boulders or construction of bank deflectors. Channel construction of low level check dams, or other "in channel" structures, should be avoided in large streams.
3. Average gradient through the stream reach of less than 3 percent. An optimum gradient for stream improvement is less than 1 percent. Streams with a gradient of greater than 3 percent should be avoided since problems of stability may occur.
4. Average August or January water depth through selected riffles or spawning areas of less than .2 inch. During low summer and winter flows, shallow water and low velocity can result in reduced productivity and spawning success, as well as contribute to winter mortality. Stream improvement designed to increase water depth and velocity can be very beneficial in such streams.
5. Wild trout population (natural reproduction) of 20 pounds per surface acre or less. A stream with this low productivity likely has poor habitat conditions which may be helped through selected stream improvement.
6. Aquatic invertebrate diversity composed of ten or less species. Low diversity of aquatic invertebrates in coldwater trout streams often indicates poor habitat conditions (velocity, siltation, etc.).
7. Less than 30 fishermen days (4.2 hrs/day) per surface acre per year of use occurring on the stream. Such a low fishermen use especially in the area of high public concentrations, indicates poor fish populations and fishermen success.
8. Excessive bank erosion which is detrimental to 50 percent or more of available spawning and food producing habitat within the stream. Siltation often occurs from bank erosion, overgrazing or cultivation within the riparian zone. Stream improvement practices may include fencing or selective bank stabilization.

If five or more of the above criteria are present in a stream which is being evaluated, it is a strong indication that properly designed stream improvement can be effective.

Along with stream improvement, consideration must be given to such factors as water quality and protection of the stream against dewatering. Regarding minimum stream flows, we are happy in Colorado to have one of the few laws giving legal protection to the maintenance of flows and natural lake levels for fishery purposes. This law, Senate Bill 97 (37-92-102(3), C.R.S., was passed in 1973 and established that maintenance of stream flows and lake levels was a beneficial use and a legal appropriation of water in Colorado. In May 1979 the Supreme Court in Colorado ruled that the law was constitutional. Presently the Colorado Division of Wildlife has made recommendations for flows in over 500 streams and for levels in approximately 450 natural lakes. The stream mileage exceeds a length of 3,200 miles and includes some of Colorado's finest trout waters. This law and the Supreme Court ruling is perhaps one of the greatest accomplishments that has occurred in assuring the future protection of Colorado's trout resources. Without it I can assure you that no matter how well our wild trout management activities are developed we would be very vulnerable to future losses of streams due to dewatering. It is the intent in the future to purchase water rights on selected streams to assure continued maintenance of trout fisheries.

In many quarters among fishermen there is a very strong pessimism toward fish hatcheries and the so-called "put and take" programs. Colorado operates 11 coldwater fish hatcheries and rearing units that produce approximately 4 million catchable and 20 million subcatchable trout annually. These are predominently rainbow trout but also include brooks, browns, natives and graylings. The Division has been making a strong effort for the past three years to develop its own rainbow trout brood stock. This brood stock is composed of various subspecies of rainbow including Tasmanian, Arlees and De Smet strains. The Tasmanian and Arlees have fall spawning traits which is of importance in establishing natural reproducing populations of rainbow trout in Colorado's waters that now tend to contain loadings of suspended solids during spring runoff which may smother eggs of spring spawning trout. In addition to rainbow brood stock, progress has also been made in selectively establishing areas where streains of native trout exist. Colorado is fortunate to have isolated populations of the Yellowstone and Colorado River, Greenback and Rio Grande cutthroat trout. Eggs taken from these sources are hatched in rearing units and are being systematically used to restore native populations in historic waters. In waters where populations of the above listed varieties of cutthroat do not currently exist, the Snake River cutthroat is being experimentally planted in selected waters.

The major thrust of a hatchery program is, of course, in raising a catchable product. The great majority of catchable fish are not stocked in streams on top of wild trout populations but instead are primarily used in fluctuating, unproductive reservoirs. Out of a total 8,700 miles of trout streams, catchable trout are stocked in approximately 2,000 miles which are close to population centers and areas of heavy fishing pressure. It is the intent of Colorado to maintain a strong hatchery system that will be properly used for the benefit of all fishermen including those who wish to bait fish sitting in a lawn chair next to a reservoir, as well as the discriminating angler who prefers to fish for so-called wild trout in a natural stream setting.

The future of Colorado's fish management program can best be summed up with one word -- diversity. Emphasis will be given to a broad range of fish management goals including the maintenance of wild trout fisheries. This goal will, of course, be pursued in relation to the number of waters that exist which support wild trout management. It must also be recognized that the catchable product will be a way of life in the future in Colorado to meet the needs of many fishermen. We will also place continued emphasis on preservation and protection of aquatic habitat. Perhaps this goal is the single most important toward preserving the quality of trout fishing. To fully realize successful fish management will also certainly require the continued support of an informed fishing public.

YOU'RE THE SOLUTION TO WATER POLLUTION

ENVIRONMENTAL EXTREMES AND NATIVE BROOK TROUT POPULATIONS IN THE SOUTHEASTERN UNITED STATES[1]

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Abstract.--The effects of environmental extremes on two brook trout populations in the Southeast were documented during a 2-year study on the Tye River, Virginia. Brook trout suffered high mortalities during summer drought and winter ice conditions but exhibited a propensity for rapid recovery during subsequent periods.

INTRODUCTION

Native brook trout (Salvelinus fontinalis) populations in the southeastern United States have steadily declined since 1900 and now are primarily restricted to small headwater streams above 600 m elevation. The current estimate of native brook trout streams in the Southeast is 3175 km (Seehorn 1978).

Headwater trout streams are generally characterized by steep gradients, infertile water, large boulders, abundant overstory and instream cover. Habitat degradation and environmental extremes have significant adverse impacts on native stocks in these areas of the Southeast. Industrialization, urban sprawl, hydroelectric development, channelization, road construction, logging, mining and introduced species reduce brook trout habitat (Schuder 1979) while droughts, seasonal floods and snow and ice reduce brook trout abundance (LaRoche 1979). With the steady decline in range, available habitat and increase in fishing pressure, it has become particularly important that the impact of environmental extremes on native brook trout populations be evaluated, so that proper conservation and management techniques can be employed.

IMPACT OF ENVIRONMENTAL EXTREMES

Drought

Due to the warm climate and headwater location of trout streams in the Southeast, extended periodic droughts often result in low surface and groundwater flows and elevated stream temperatures. The impact of low flows on trout populations can be devastating. Many authors (Brett 1951; Benson 1953; Wickett 1958; Lennon 1961; Latta 1965; Corning 1969, McNeil 1969; Havey and Davis 1970; LaRoche 1979) have found a direct correlation between amount of surface and groundwater flow and population size. Reduction in flow can affect reproduction in salmonid populations by: 1) restricting upstream migration of adults and subsequent egg deposition; 2) creating overcrowded conditions and redd superimposition; and 3) creating excess stress on adult spawners and poor egg development.

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[1]Paper presented at the Wild Trout Symposium II, September 24 and 25, 1979, Yellowstone National Park, Wyoming.

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[3]Cooperators are the Commission of Game and Inland Fisheries, the Virginia Polytechnic Institute and State University, and the United States Fish and Wildlife Service.

Adult and juvenile losses from the drought conditions are perhaps more serious than reduced egg survival because of lost reproductive potential. Low flow, increased competition, dwindling food supplies and vertebrate predation are major contributors to adult and juvenile losses. Small trout are able to survive low flows because they can feed in shallow riffle areas, while large trout are forced to remain in the less productive pools (Corning 1969).

Drought and reduced flows increase water temperature and cause mortality in trout populations (Embody 1921; McCormick 1972). Mortalities result from increased susceptibility to pathogens such as Chondrococcus columnaris (Sniezko 1974) behavioral changes toward predators (Sylvester 1972) or thermal stress (Lennon 1961).

Floods

Floods produced by spring rains, melting snows, and occasional hurricanes periodically occur in the southeastern United States. Since most trout streams in this area possess steep gradients, high flows can greatly reduce trout production through streambed scouring, sedimentation and shifts in species composition.

Scouring destroys redds and produces above normal mortality of eggs and fry (Allen 1951; McNeil 1969; Hausle and Coble 1976). Scouring also reduces food production through mortality of food organisms and forced movement out of the stream (Needham and Jones 1959; Lennon 1961).

Many authors (Allen 1951; Wickett 1958; Elwood and Waters 1969; McNeil 1969; Seegrist and Gard 1972; Hoopes 1975) have related floods and high flows to reductions in salmonid standing stocks. Mortalities can occur as a result of the flooding itself or from reduced habitat by sedimentation in productive riffle and pool areas. Sedimentation not only reduces food and suitable habitat (Saunders and Smith 1965; Bjornn et al. 1977) but may increase egg mortality in redds through a reduction in inter-gravel water flow (Hausle and Coble 1976) or emergence of embryos (Shelton and Pollock 1966).

Floods may cause shifts in species composition through differential colonization rates. Winter floods in Sagehen Creek, California reduced brook trout densities and allowed spring spawning rainbow trout (Salmo gairdneri) to expand their populations (Seegrist and Gard 1972). Immigration by other trout species into flood-damaged areas can also occur when brook trout densities are reduced (Hanson and Waters 1974).

Snow and Ice

The Southeast is not an area commonly associated with heavy snows and extended periods of subfreezing temperatures. It is not uncommon however to have heavy winter snows, ice formation and below zero temperatures in the higher elevations of the Appalachian Mountains where most trout streams are located.

Winter mortality of brook trout can be caused by: 1) collapsing snow and ice shelves, causing death by crushing or suffocation against the stream substrate; 2) snow and ice dams which dewater stretches of stream and side channels and 3) floods resulting from collapsing ice dams (Needham et al. 1945; Needham and Jones 1959). Prolonged surface ice or snow cover can reduce light, periphytic algae and food organisms (Reimers 1957) and also cause fish mortality when combined with adverse stream conditions.

Mortality of eggs in natural redds from adverse winter conditions does not appear to be as severe as adult and juvenile losses in Michigan streams (Benson 1955). Trout fry in the egg-sac stage are vulnerable however at the time of emergence, and mortality can occur if ice forms during emergence. Artificial redds have a similar problem and in situ freezing is possible when Vibert boxes are used (Reiser and Wesche 1979). Freezing can occur even when physical and hydraulic conditions appear suitable.

CASE STUDY

The impact of two consecutive years of summer drought and a winter of heavy surface and anchor ice on brook trout was evaluated in a two-year study (1977-78) on the North and South Forks of the Tye River in central Virginia. The North and South Forks are located in the western corner of Nelson County in the Blue Ridge Physiographic Province of central Virginia. This area is characterized by heavily wooded (oak-hickory-birch) broad-topped ridges reaching 1220 m in elevation (LaRoche 1979).

These rivers are second order, cold-water tributaries of the James River drainage, and flow in an east-southeast direction to form the Tye River at Nash, Virginia. The streams are similar in chemical and physical makeup, and are considered by many the finest native brook trout streams in Virginia. The two streams were stocked in the downstream study sites with brook, rainbow and brown trout (Salmo trutta) during the study period.

METHODS

Fish population samples were taken quarterly from three 50-m sections within the unstocked and stocked areas of each stream. Quarterly samples were collected with a Coffelt BP-3 battery backpack shocker or a 230 volt shore-based Georator unit. Each section was blocked with small-mesh seines to prevent emigration from or immigration into the section. Three depletion runs were then made through each section for population and biomass estimates. Population estimates were determined by the weighted maximum likelihood removal estimation technique of Carle and Strub (1978). Significant differences in abundance between sampling quarters were determined by Duncan's Multiple Range Test ($p<0.05$) (Barr et al. 1976). Age structures, growth rates, condition factors (K_{TL}) and length-weight relationships were calculated using a computer program package developed by Hesse (1977). For comparative purposes, surface area measurements for each sampling station were determined on a "one time only" basis during low flows in late summer.

RESULTS AND DISCUSSION

During this study, there were two periods when extreme decreases in population and biomass estimates took place in both the sport and non-game fishes of the two streams (Fig. 1). These two periods occurred between the summer of 1977 and the spring of 1978, and between the summer and fall of 1978. The most probable explanations for the population reduction during these periods were severe summer drought, high water temperature and over-winter mortality due to ice formation.

A drought in late spring and summer occurred in central Virginia during 1977. Rainfall from April through September 1977 totaled 3.8 cm, 36% below the 17-yr average (Johnson et al. 1975). Although this decline does not appear extreme, rainfall was limited almost exclusively to short afternoon downpours with rapid runoff. Following the drought, Virginia had one of the wettest and coldest winters on record. Heavy snow and ice ledges, anchor ice formation and below zero temperatures lingered until mid-March. A drought also occurred in 1978, during late summer and fall. Rainfall from August 1978 through October 1978 totaled 0.9 cm, 72.5% below the 17-yr average rainfall for these three months (Johnson et al. 1975). Because the drought occurred in late summer and fall, water temperature was not considered a factor in fish mortality. However, water levels at this time were at their lowest point during the entire study period, and were thought to be a major cause of fish mortality. Discharge determined on 1 September 1978 on the North Fork ranged from 0.24 m^3/s at the upper-most station to only 1.07m^3/s at the downstream station. Similar discharge rates were evident on the South Fork.

Population estimates and condition factors in July 1977 indicated that fish populations of the North and South Forks had not been severely impacted by the drought at that time. Condition factors for adult native brook trout averaged 0.986 for trout for the North Fork, while South Fork trout averaged 1.033. Condition factors for age 0 native brook trout were similar. Estimates of summer trout abundance and biomass indicated high population densities and possible overcrowding in most areas of the two streams. Population and biomass estimates ranged from a low of 1,505 trout/ha (20.0 kg/ha) in the lower South Fork to a high of 3,635 trout/ha (51.3 kg/ha) in the unstocked area of the North Fork. These exceptionally high densities were largely age 0 brook trout (53-69%).

The summer drought of 1977 was followed by frequent rains in autumn. Only the unstocked section of the North Fork could be sampled during the fall because of high flows. Standing stock estimates indicated a significant decrease in native brook trout abundance and biomass. Native brook trout estimates in autumn were 2,011 trout/ha (20.7 kg/ha), decreases of 45 and 60%, respectively from summer estimates. We believe that low water levels and higher water temperatures had a profound effect on the native brook trout populations of these two streams due to the following: 1) overcrowding and increased competition for food, 2) increased vulnerability to predation and 3) temperature-related mortality. The average condition factor for brook trout during the fall sample was a low 0.790 for adult trout and 0.952 for age 0 trout. Adult trout were impacted most by the drought, decreasing 52% in abundance compared to 39% for age 0 trout. Besides the impact of reduced standing stocks, the summer drought of 1977 also created an additional impact. Periodic checks of native brook trout for sex products in the fall of 1977 indicated poor gonadal development, especially among females. What little food was available during the summer months was

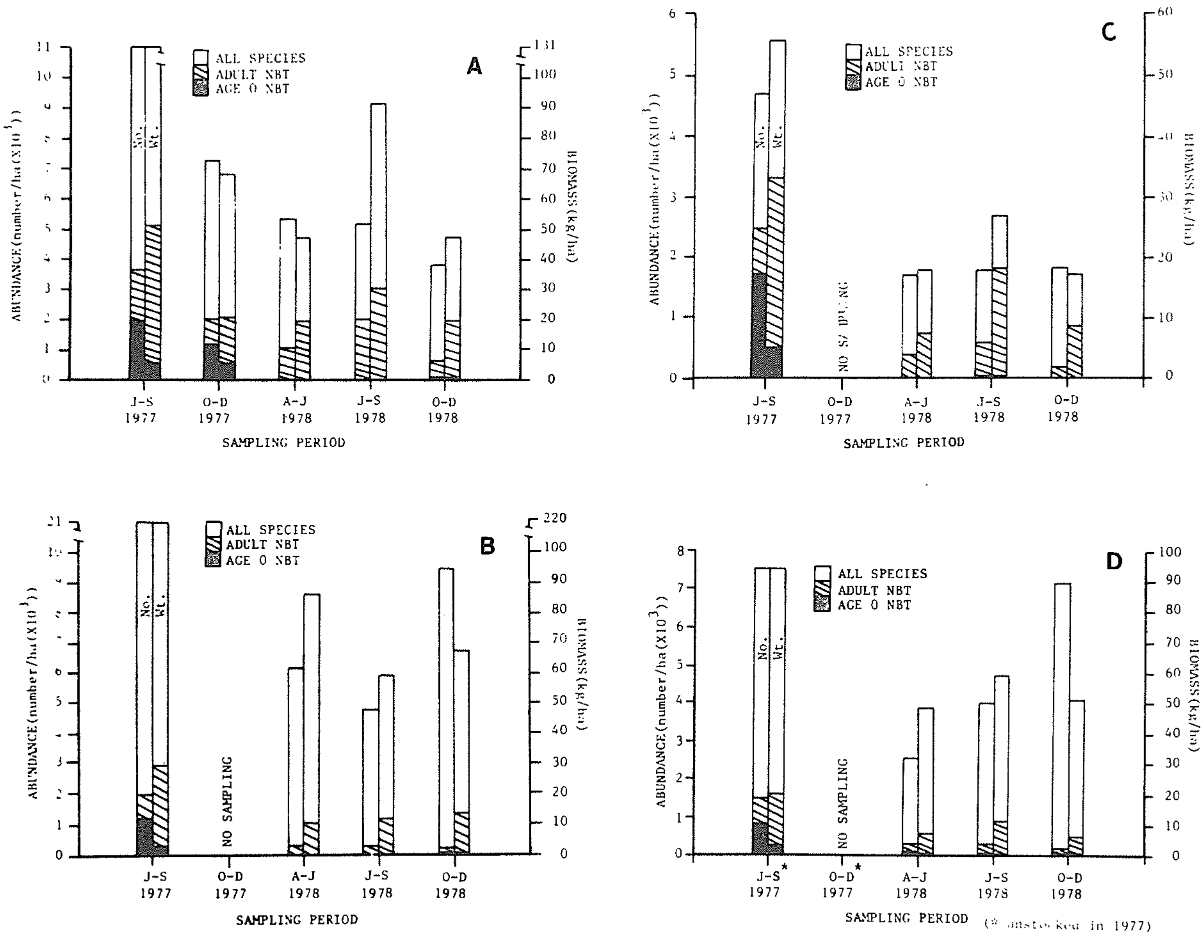

FIGURE 1. ABUNDANCE AND BIOMASS ESTIMATES FOR ALL SPECIES COMBINED, AND ADULT AND AGE 0 NATIVE BROOK TROUT (NBT) IN THE UNSTOCKED (A) AND STOCKED (B) AREAS OF THE NORTH FORK AND THE UNSTOCKED (C) AND STOCKED (D) AREAS OF THE SOUTH FORK, TYE RIVER, VIRGINIA, 1977 AND 1978.

apparently used for maintenance and not for gonadal development. Poor reproductive development combined with few adults in autumn 1977 led to prediction of a poor 1978 year class.

Population estimates were not possible during the winter of 1977-78, since it was one of the coldest and wettest on record for Virginia. Heavy snows, complete ice coverage of the streams and frequent subfreezing temperatures made the streams inaccessible until the first week of April when spring sampling was initiated. Significant decreases in population abundance and standing stock estimates of native brook trout were found in spring 1978. The native population of the South Fork suffered the heaviest loss, declining 84.2% in upstream unstocked areas and 80.1% in downstream stocked areas. The native population on the North Fork declined 70.3% and 81.5% in unstocked and stocked areas, respectively. Standing stock estimates during spring 1978 ranged from a high of 1,079 trout/ha (18.7 kg/ha) in the unstocked North Fork, to 299 trout/ha (7.4 kg/ha) in stocked areas of the South Fork. Age 0 trout were captured only at the lowest station on the South Fork.

Population estimates in summer 1978 revealed that native brook trout populations of the two streams were similar to those from the spring 1978 sample. However it was apparent that the 1978 year class was absent. No age 0 native brook trout were captured in the North Fork during the summer 1978 sampling while few occurred in the South Fork. In contrast, summer 1977 sampling indicated that 1,927 and 1,190 age 0 trout/ha resided in the unstocked and stocked areas of the North Fork, respectively. In the South Fork estimates of age 0 trout/ha in the unstocked areas dropped from 1,703 in 1977 to 23 in 1978 and from 825 to 68 in the stocked areas, decreases of 98.7% and 91.8%, respectively. The drought of 1977 and the winter of 1977-78 had not only a substantial impact on the adult native brook trout populations of the North and South Forks, but virtually eliminated the 1978 year class.

The second consecutive summer drought occurred in late summer 1978, with water levels falling to the lowest point during the study. In conjunction with this drought, abundance and biomass estimates for native brook trout again declined. Population estimates in fall 1978 revealed losses ranging from a low of 14.6% in the stocked areas of the North Fork to a high of 71.0% in the unstocked area of the South Fork. Population abundance and biomass estimates for the North Fork were 240 trout/ha (13.5 kg/ha) in the stocked area and 544 trout/ha (19.3 kg/ha) in the unstocked area. These figures represent decreases of 87.6 and 85.0% since the initial estimates in July 1977. Standing stocks for the South Fork were 159 trout/ha (6.1 kg/ha) in stocked areas and 171 trout/ha (8.5 kg/ha) in unstocked areas, representing decreases of 89.4 and 93.1% since the initial sampling.

Although water levels were low in fall 1978, native brook trout were in good condition compared to 1977. Condition factors averaged 0.949 for trout from the North Fork, and 1.019 for the South Fork. Gonadal development was excellent in 1978. The improved condition factors for these trout even during a substantial drought indicate that lower density caused by the 1977 drought reduced competition for food in 1978. The drought of 1978 occurred in late summer and early fall when higher water temperatures were probably not critical to egg development.

In conclusion, this study points out the high vulnerability of trout populations in the Southeast to environmental extremes. Fisheries managers should be aware that environmental extremes may well be the greatest limiting factor in the fish production of native trout streams. With a cessation of stocking, native brook trout populations have the resiliency to recover from environmental extremes. Without such management, other less desirable species may replace this declining resource.

ACKNOWLEDGMENTS

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LITERATURE CITED

Allen, K. R. 1951. The Horokiwi stream, a study of a trout population. New Zealand Mar. Dep. Fish. Bull. No. 10, 231 pp.

Barr, A. J., J. H. Goodnight, J. P. Saul, and J. T. Helwig. 1976. A users guide to SAS 76. SAS Institute, Inc., Raleigh. 329 pp.

Benson, N. G. 1953. The importance of ground water to trout populations in the Pigeon River, Michigan. Trans. N. Am. Wildl. Conf. 18:258-281.

__________. 1955. Observations on anchor ice in a Michigan trout stream. Ecology 3:529-530.

Bjornn, T. C., M. A. Brusven, M. P. Molnau, J. H. Milligan, R. A. Klamt, E. Chacho, and C. Schaye. 1977. Transport of granitic sediment in streams and its effect on insects and fish. Res. Tech. Rep. OWRT Project No. B-036-IDA, Forest, Wildlife and Range Exp. Station, Univ. of Idaho, Moscow. 43 pp.

Brett, J. R. 1951. A study of the Skeena River climatological conditions with particular reference to their significance in sockeye production. J. Fish. Res. Board Can. 8:178-187.

Carle, F. L., and M. R. Strub. 1978. A new method for estimating population size from removal data. Biometrics 34:621-630.

Corning, R. V. 1969. Water fluctuations, a detrimental influence on trout streams. Proc. Annu. Conf. Southeast Assoc. Game Fish Comm. 23:431-454.

Elwood, J. W., and T. F. Waters. 1969. Effects of floods on food consumption and production rates of a stream brook trout population. Trans. Am. Fish. Soc. 98:253-262.

Embody, G. C. 1921. Concerning high water temperatures and trout. Trans. Am. Fish. Soc. 51:58-61.

Hanson, D. L., and T. F. Waters. 1974. Recovery of standing crop and production rate of a brook trout population in a flood-damaged stream. Trans. Am. Fish. Soc. 103:431-439.

Hausle, D. A., and D. W. Coble. 1976. Influence of sand in redds on survival and emergence of brook (Salvelinus fontinalis). Trans. Am. Fish. Soc. 105:57-63.

Havey, K. A., and R. M. Davis. 1970. Factors influencing standing crops and survival of juvenile salmon at Barrows Stream, Maine. Trans. Am. Fish. Soc. 105:57-63.

Hesse, L. 1977. FIRE I: a computer program for the computation of fishery statistics on samples of aged and non-aged subsamples. Nebraska Game Parks Comm. Tech. Ser. No. 1. 60 pp.

Hoopes, R. L. 1975. Flooding as the result of hurricane Agnes and its effects on a native brook trout population in an infertile headwater stream in central Pennsylvania. Trans. Am. Fish. Soc. 104:96-99.

Johnson, T. W., J. Wysor, and R. Marchany. 1975. User's Guide for HISARS (Hydrologic Information Storage and Retrieval System), Virginia Water Resources Research Center, Blacksburg, VA. 78 pp.

LaRoche, A. L., III. 1979. The impacts of stocking hatchery reared trout on the native brook trout populations of two streams in central Virginia. M.S. Thesis, VPI & SU, Blacksburg, VA. 202 pp.

Latta, W. C. 1965. Relationship of young-of-year trout to mature trout and ground water. Trans. Am. Fish. Soc. 94:32-39.

Lennon, R. E. 1961. The trout fishery in Shenandoah National Park. Bur. Sport Fish. and Wildl. Spec. Sci. Rep. Fish. No. 395. 16 pp.

McCormick, J. H. 1972. Effects of temperature on growth and survival of brook trout (Salvelinus fontinalis). J. Fish. Res. Board Can. 29:1107-1112.

McNeil, W. J. 1969. Survival of pink and chum salmon eggs and alevins. Pages 101-117 in Northcote, T. G. (ed.) Symposium on Salmon and Trout in Streams. H. R. Macmillan Lectures in Fisheries. Univ. B.C.

Needham, P. R., J. W. Moffett, and D. W. Slatter. 1945. Fluctuations in wild brown trout populations in Convict Creek, California. J. Wildl. Manage. 9:9-25.

Needham, P. R., and A. C. Jones. 1959. Flow temperature, solar radiation, and ice in relation to activities of fishes in Sagehen Creek, California. Ecology 40:465-474.

Reimers, N. 1957. Some aspects of the relation between stream foods and trout survival. Calif. Fish Game 43:43-69.

Reiser, D. W., and T. A. Wesche. 1979. In situ freezing as a cause of mortality in brown trout eggs. Prog. Fish-Cult. 41:58-60.

Saunders, J. E., and M. W. Smith. 1965. Changes in a stream population of trout associated with increased silt. J. Fish. Res. Board Can. 22:395-404.

Schuder, Gerald D. 1979. The changing Southeast - the evolution of a trout resource. Trout 29(1):6-9.

Seegrist, D. W., and R. Gard. 1972. Effects of floods on trout in Sagehen Creek, California. Trans. Am. Fish. Soc. 101:478-482.

Seehorn, Monte E. 1978. Status of brook trout in the Southeast. Brook Trout Workshop, Asheville, N.C., December 5-8, 1978. (Abstract)

Shelton, J. M., and R. D. Pollock. 1966. Siltation and egg survival in incubation channels. Trans. Am. Fish. Soc. 95:183-187.

Snieszko, S. F. 1974. The effects of environmental stress on outbreaks of infectious diseases of fishes. J. Fish. Biol. 6:197-208.

Sylvester, J. R. 1972. Effects of thermal stress on predator avoidance in sockeye salmon. J. Fish. Res. Board Can. 29:601-603.

Wickett, W. D. 1958. Review of certain environmental factors affecting the production of pink and chum salmon. J. Fish. Res. Board Can. 14:1103-1126.

IMPACTS OF ACID PRECIPITATION

ON TROUT WATERS[1]

Carl L. Schofield[2]

Abstract.--Extensive lake acidification and loss of fish populations has occurred in geologically sensitive regions of eastern North America and Scandinavia, which currently receive precipitation more acid than pH 4.6-4.7. Restoration of acidified lakes in the Northeast would require a 60-70% reduction in precipitation acidity. Projected trends of increased SO_2 and NO_x emissions from fossil fuel combustion suggest continued acidification and additional loss of trout resources.

INTRODUCTION

Acid precipitation is currently a widespread, regional phenomenon in eastern North America, western Europe and Scandinavia. Annual average pH levels of 4.0-4.2 (weighted for volume) have been reported for precipitation in these regions, with pH values as low as 2.4-3.0 recorded for individual rain events in several locations (Likens et. al. 1979). In the northeastern United States, about 60-80% of the acidity in precipitation is due to sulfuric acid, with nitric acid accounting for most of the remaining contribution. Anthropogenic emissions of SO_2 and NO_x to the atmosphere are believed to be the major sources of strong acids found in precipitation. On a global scale, man-made sulfur loading to the atmosphere (65-70 Tg/year) is currently about equal to or slightly exceeds all known natural sources of sulfur emission (eg. volcanoes, biological decomposition). Approximately 61% of the global anthropogenic sulfur emission occurs over less than 5% of the earth's surface area, principally in western Europe and eastern North America. Fossil fuel combustion is the primary source of SO_2 emissions in these industrialized regions and of the 31 Tg of SO_2 emitted annually in the United States, approximately 53% is from utility coal combustion. Some 75% of the total U.S. SO_2 emissions occur east of the Mississippi River. The trend toward fewer but larger SO_2 sources involving higher stack emission points and a tendency to locate away from urban areas and toward rural locations, has caused the emitted sulfur to be distributed over wider areas. Transformation of gaseous SO_2 emissions to acid sulfates (eg. H_2SO_4 and NH_4SO_4 aerosols) results in the production of sub-micron size particles, which have a long atmospheric residence time (3-5 days). Thus, the impact of sulfate pollutants can extend over 1,000 km. or more from the original sulfur dioxide source (Anonymous 1978). Precipitation scavenging or wash out is the primary means by which these acid pollutants are removed from the atmosphere, thus creating the phenomenon known as acid precipitation.

[1]Paper presented at the Wild Trout II Symposium, Yellowstone National Park, Wyoming, September 24-25, 1979.

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The long term effects of acid precipitation on aquatic and forested ecosystems, agriculture, man-made structures, and human health are potentially numerous and complex, but at this point are largely unknown. Only in sensitive aquatic ecosystems have serious impacts been recognized and investigated intensively. This paper will consider the known and potential impacts of acidification on trout resources in sensitive regions of North America and Scandinavia.

LAKE ACIDIFICATION

Lake acidification is one of the most severe ecological impacts associated with the acid precipitation phenomenon. Acidified lakes exhibit alterations in water quality which in turn lead to drastic changes in the structure and function of the lake ecosystem. Loss of bicarbonate buffering, decreased pH, and increased mobility of toxic metals are the primary chemical changes associated with acidification. Biological responses to acidification which have been observed include extinction of fish populations, decreased productivity, inhibition of decomposition and nutrient cycling, and simplification of community structure, as a result of decreased species diversity. The problem is regional in scale and has affected extensive lake districts in Scandinavia and eastern North America (Likens 1976; Gorham 1976).

The sensitivity of lakes to acidification by acid precipitation is determined largely by the ability of their terrestrial watersheds to neutralize the acid inputs. Thus, waters draining regions characterized by granitic or other hard, weathering resistant bedrock formations overlain by thin, base deficient soils would have minimal acid neutralizing capacity. Numerically, the vast majority of salmonid waters in Norway, Sweden, Canada, and the United States fall into this vulnerable category. The pristine, dilute oligotrophic lakes of these sensitive regions normally have pH levels above 6.0, and bicarbonate is the major anion (Wright and Gjessing 1976). The acidification of these sensitive waters by acid precipitation is analogous to a regional scale "Titration" of a bicarbonate solution by strong mineral acids (eg. H_2SO_4 from precipitation). The titration curve, relating pH change to acid input, can be segmented into three stages which define both the extent and nature of water quality change and the biological impacts. The initial stage of acidification is characterized by decreasing alkalinity, but maintenance of bicarbonate buffering and pH levels above 6. No significant impacts on fish populations have been observed at this level of acidification. Loss of bicarbonate buffering, with associated severe, temporal drops in pH occur in the second stage of acidification. Physiological stress, reproductive inhibition, and episodic mass mortalities may initiate recruitment failure and eventual extinction of fish populations during this stage of acidification. The final stage of acidification is characterized by chronically depressed pH levels (less than pH 5) and elevated toxic metal concentrations (eg. aluminum). Fish are generally absent from waters at this level of acidification. This generalized view of the acidification process and corresponding impact levels on fish populations is supported by extensive, carefully documented data from impacted sensitive regions in Norway (Wright and Snekvik 1979) and eastern North America (Schofield 1976; Beamish et. al. 1975).

More recently, Henriksen (1979 a.b.) has developed models of the acidification process which quantitatively relate the stages of acidification described above to precipitation acidity levels and acid neutralizing capacity (calcium levels) in sensitive regions. Acidification is quantitatively expressed as the decrease in alkalinity which results from an equivalent increase in strong acid input. Alkalinity in pristine lakes is due primarily to bicarbonate, which is accompanied by a proportional amount of calcium derived from normal weathering processes. Acidification of such waters is thus reflected by the replacement of bicarbonate by sulfate (from H_2SO_4 in precipitation) as the major anion. Pristine, neutral calcium-bicarbonate waters are transformed to acidic hydrogen-calcium-sulfate waters. Estimates of the amount of acidification that has occurred in any given region are obtained by comparing the calcium-alkalinity relationship observed in waters from the impacted region to that expected for a pristine area. For given levels of calcium, the deficiency in alkalinity observed for lakes in impacted regions, relative to pristine areas, is taken as a measure of the amount of acidification which has occurred. Differences in excess sulfate concentration (above background contribution from geologic weathering or sea-salt aerosols) provide a comparable measure of acidification. Utilizing these relationships Henriksen (op. cit.) determined acidification levels for a large number of lakes in southern Norway. He found that these levels of acidification were linearly related to the weighted average hydrogen ion concentration of precipitation at each lake. Nomograms were developed from these empirical relationships, which allow prediction of lake pH, given only lake calcium concentration and pH of precipitation. Application of these models to sensitive regions in North America also resulted in accurate predictions of observed lake pH and levels of acidification, suggesting that the process of acidification, described by the models, is universal in regions with comparable geologic settings (Henriksen 1979 a.; Schofield 1979). These models provide a basis for predicting both the regional extent and levels of acidification which have already occurred in sensitive areas and more significantly, they can be used to predict the effects of future changes in precipitation acidity on sensitive aquatic ecosystems.

Significant levels of acidification have been detected or are expected in sensitive regions which currently receive precipitation more acidic than pH 4.6-4.7. In addition to southern Norway and southwestern Sweden, areas in North America which fall into this category include New York, northern New England, the Appalachians, south-central Ontario, and southern Quebec. In addition, precipitation pH levels are currently only slightly above this critical level for initiation of acidification in sensitive areas of northeastern Minnesota, Wisconsin, Michigan, and north-central Florida. Severe lake acidification (pH levels below 5 and complete loss of fish) has already occurred in regions such as the Adirondack Mountains of New York where precipitation pH currently averages between 4.0-4.2 on an annual basis. Restoration of these lakes to a pristine state would require a minimum reduction in precipitation acidity of 60-70%.

EXTENT OF IMPACTS ON SALMONID WATERS

As indicated previously, waters sensitive to acidification by acid precipitation are characterized by inherently low acid neutralizing capacity and drainage systems situated in areas of crystalline or metamorphic bedrock with shallow, acid soils. These conditions are prevalent in the mountainous areas of the eastern and western United States, precambrian shield regions of eastern Canada, Norway and Sweden. The fish fauna inhabiting the dilute, oligotrophic waters characteristic of these regions vary considerably in species composition but are typically dominated by salmonids. Thus, it is principally our esteemed pristine trout waters that are prone to the impacts of acidification.

In Norway, acidification has resulted in the loss of fish populations from more than 20% of the waters in a 33,000 km^2 area south of 63°N (Wright and Snekvik 1979). Brown trout (Salmo trutta), char (Salvelinus alpinus), and salmon (Salmo salar) populations are the primary species affected in this area. Massive kills of salmon and brown trout have been reported in several river systems in southern Norway, usually in association with episodic increases in acidity from spring snow melt (Leivestad and Muniz 1976).

The area already affected by acidification in Sweden has been estimated as 90,000-110,000 km^2, comprising about 20,000 lakes (20% of the total number of lakes in Sweden). This represents a loss in annual yield of commercially valuable fish of some 3,000,000 kg., valued at approximately 16.5 million dollars[3]. The west coast area is the most heavily impacted region in Sweden, where more than 50% of the lakes have experienced acidification. Char, sea trout, and salmon are the primary species affected in this region.

[3]Report of estimated financial damage to aquatic systems by acidification from Swedish Ministry of Agriculture to OECD

The effects of acidification on fish populations in Ontario, Canada resulting from emissions at the Sudbury, metal smelting complex are well documented (Beamish et. al. 1976), but only recently have Canadian scientists discovered that the problem is of potentially greater magnitude in eastern Canada. Critically acid levels in precipitation over southern Ontario, Quebec, and the Maritimes have been related to the regional spread of acid precipitation in eastern North America from emission sources on both sides of the border. More than 40,000 lakes in these areas are potentially threatened by acidification at this time (Dillon et. al. 1977).

The Adirondack lake district in northern New York is currently the most heavily impacted region in the eastern United States. More than half of the high elevation lakes of this region have been acidified to the point where they no longer support fish life (Schofield 1976). Heritage populations of wild brook trout (Salvelinus fontinalis) have been lost to acidification and the few remaining wild population are threatened with extinction. Acidification of some of the mountain lakes in western Maine and New Hampshire has been detected (Davis et. al. 1978), but as yet the impacts on trout populations have not been determined. Similarly, acidification of headwater trout streams in areas of Pennsylvania, West Virginia, and other mountainous regions of the southeastern United States may already be occurring but no documentation of fisheries impacts are currently available.

CAUSES OF FISH MORTALITY

Surveys conducted in acidified regions all reveal general relationships between fish survival, species diversity, and pH, with most fish populations exhibiting perturbations below about pH 5 (Schofield 1976; Wright and Snekvik 1979). Although hydrogen ion concentration has been identified as the "master" variable involved in fish responses to acidification, other chemical species are important in determining modes of toxicity and regulating tolerance to given levels of hydrogen ions. Calcium is of primary significance in ameliorating hydrogen ion toxicity and osmoregulatory stress, through control of cell membrane permeability and ion transport at the level of the gill. Unacclimated fish exposed to low calcium, acid environments may experience severe sodium imbalance as a result of changes in gill permeability (Evans 1975).

Elevated aluminum concentrations, typically found in acidified lakes and streams as a result of soil leaching by acid precipitation, are potentially toxic to fish at pH levels which are otherwise not directly harmful. Aluminum toxicity to fish is also exerted at the level of the gill and may involve damage to respiratory epithelium, in addition to osmoregulatory disturbance. The speciation of aqueous aluminum in acidified waters is controlled primarily by pH and the concentrations of flouride, sulfate, and organic ligands. Toxicity appears to be exerted primarily by the inorganic species of aluminum, which are predominant in acidified lake and stream water during periods of increased surface runoff. Organic complexes of aluminum, which are formed in the process of soil podzolization, are not toxic to fish. It is thus primarily the superimposition of anthropogenic acidification (acid precipitation) on the natural process of soil acidification (podzolization) that leads to the production of toxic species of aluminum in surface waters of sensitive regions (Cronan and Schofield 1979; Driscoll et. al. 1979).

Acidified lakes which have lost bicarbonate buffering and maintain chronically depressed pH (less than 5) are generally devoid of fish life. Less acidic, but poorly buffered waters experience episodic acidification during snow melt and periods of heavy precipitation when their inherent acid neutralizing capacity is temporarily overwhelmed. Fish mortalities, which occur during these episodes as a result of stresses associated with the extreme temporal variations in pH and metallic cations, can lead to recruitment failure and alteration in population structure. The relative importance of these temporal, but acute impacts and longer term chronic stresses associated with acidification, to population extinction is currently unknown. Reproductive failure resulting from disruption of spawning behavior, inhibition of gonad maturation, and egg-larval mortality have all been described as sources of recruitment failure affecting fish populations in acidified regions (Schofield 1976).

Adaptation of fish populations to acidified environments may occur as a result of several factors. Inter and intraspecific variations in physiological tolerance to acidified waters have been described (Robinson et. al. 1976) and genetically controlled intraspecific variations in life history patterns (eg. time of spawning) may also contribute to population success or failure in acidified regions. Although there is experimental evidence and some field observations which suggest the potential for adaptation of fish populations to acidified environments, either through processes of natural selection or acclimation, the fact that this has not occurred naturally suggests that acidification has occurred too rapidly for these adaptive processes to work effectively in the natural environment.

PROGNOSIS FOR SENSITIVE REGIONS

There are several categories of risk associated with intensified or expanded acidification of lakes and streams. The widespread extinction of fish populations has already resulted in some reduction in genetic diversity at the species levels. This has implications for the maintenance of species integrity, but perhaps more important and of more immediate concern is the problem of species reestablishment in acidified regions. Many of the wild trout populations eliminated from areas in Sweden, Norway, and North America, although not themselves endangered species, were strains or races uniquely adapted to these environments and in this sense are irreplaceable. The alterations in ecosystem structure and function that occur when fish are removed can, in conjunction with other perturbations associated with acidification, lead to the development of aquatic ecosystems that are difficult to completely rehabilitate.

Liming is one means of chemically restoring acidified lakes, but it is not a solution to the problem. The Swedish government recently initiated a five year, 12 million dollar program to examine the possibilities for restoring badly acidified waters by liming. This program is expected to cover only about 10% of the acute need for lime treatment in Sweden. If liming were to be used to compensate for the total estimated acidification, the Swedish government estimates the cost would be 1500-3500 million dollars. It is clear from this example that liming cannot be employed extensively as the sole solution to the problem of acidification. Used selectively and judiciously, liming does have a place in regional management programs for preserving valuable fish stocks. Other "interim" measures which have potential value for maintaining fisheries in acidified regions include development of acid tolerant strains of trout and acclimation of hatchery reared trout for restocking acidified waters. It is important that these management options be developed for application in the near future, as a trend of continued acidification seems likely.

Projections for increased reliance on fossil fuels, particularly coal, for the next few decades lead to predictions of increased emissions of sulfur dioxide and nitrous oxides in the United States. Although the distribution of these increased emissions is unknown, current trends suggest the possibility of increased levels of acid deposition in the eastern United States with further expansion of critically acid precipitation to sensitive regions in the north central States.

Acid precipitation has been recognized as one of the major global environmental problems facing industrialized nations and their neighbors today. Major, government supported research efforts to evaluate the acid precipitation phenomenon and its impact have been underway for the past five years in Norway and Sweden. This year, the President's Council on Environmental Quality recommended, and the administration has approved, a ten year, multimillion dollar program for acid precipitation research in the United States. Senator Moynihan of New York has also submitted a bill to legislatively establish a comprehensive plan for dealing with the acid precipitation problem. While these new federal programs do not in themselves offer immediate solutions to the acid precipitation problem, they do provide for the protection and rehabilitation of sensitive resources and if properly conducted can lead to ultimate abatement of the problem at the source. It is important that those concerned with the protection of our sensitive wild trout habitat take an active role in structuring the priorities and directions of these developing efforts to deal with the acid precipitation problem.

LITERATURE CITED

Anonymous. 1978. Sulfur oxides. Natl Acad. Sci., Wash., D.C., 209 pp.

Beamish, R.J., W.L. Lockhart, J.C. Van Loon, and H.H. Harvey. 1975. Long term acidification of a lake and resulting effects on fishes. Ambio 4:98-102.

Cronan, C.S. and C.L. Schofield. 1979. Aluminum leaching response to acid precipitation: Effects on high-elevation watersheds in the Northeast. Sci. 204:304-306.

Davis, R.B., M.O. Smith, J.H. Bailey, and S.A. Norton. 1978. Acidification of Maine lakes by acidic precipitation. Verh. Internat. Verein. Limnol. 20:532-537.

Dillon, P.J., P.S. Jeffries, W. Snyder, R. Reid, N. Yan, D. Evans, J. Moss, and W. Scheider. 1977. Acid precipitation in south-central Ontario: recent observation. Ont. Min. Env. Techn. Rep., 24 pp.

Driscoll, C.T., J.P. Baker, J.J. Bisogni and C.L. Schofield. 1979. Aluminum speciation in dilute acidified waters and its effect on fish. Nature (in review).

Evans, D.H. 1975. Ionic exchange mechanisms in fish gills. Comp. Biochem. Physiol. 51 A: 491-495.

Gorham, E. 1976. Acid precipitation and its influence upon aquatic ecosystems: an overview. Water, Air, and Soil Pollut. 6:457-481.

Henriksen, A. 1979 a. A simple approach for identifying and measuring acidification of fresh-water. Nature. 278:542-545.

Henriksen, A. 1979 b. A model to predict lake acidification. Science (in press).

Leivestad, H. and I.P. Muniz. 1976. Fish kills at low pH in a Norwegian river. Nature. 259:391-392.

Likens, G.E. 1976. Acid precipitation. Chem. Eng. News. 54(48):29-44.

Likens, G.E., R.F. Wright, J.N. Galloway, and T.J. Butler. 1979. Acid Rain. Sci. Amer. 241:43-50.

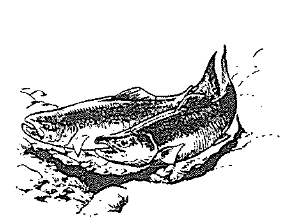
Robinson, G.D., W.A. Dunson, J.E. Wright and G.E. Mamolito. 1976. Differences in low pH tolerance among strains of brook trout.

Schofield, C.L. 1976. Acid precipitation: Effects on fish. Ambio. 5(5-6):228-230.

Schofield, C.L. 1979. Effects of acid rain on lakes. Proc. ASCE Ann. Meet., Boston (in press).

Wright, R.F. and E.T. Gjessing. 1976. Acid precipitation: changes in the chemical composition of lakes. Ambio. 5(5-6): 219-223.

Wright, R.F. and E. Snekvik. 1979. Acid precipitation: Chemistry and fish population in 700 lakes in southernmost Norway. Verh. Internat. Verein. Limnol. 20:765.



TROUT STREAM HABITAT IMPROVEMENT:

ECOLOGY AND HYDROLOGY

Robert F. Raleigh[1/] and Donald A. Duff[2/]

Abstract.--This paper presents an objective procedure to evaluate stream structural needs, based on the habitat requirements of trout species by life stage, and a guide to the design of hydraulically-sound stream structures. The effectiveness of properly designed stream improvement structures for increasing trout stocks has been amply demonstrated. Effective stream improvement projects involve two essential steps: a diagnosis of stream structural deficiencies, and the installation of stream structures designed to meet the biological and hydraulic features of the stream. Elimination of either of these essential steps can result in the failure of the stream "improvement" project. Hydraulically unsound structures can cause further stream degradation.

INTRODUCTION

Trout stream improvement projects, when well planned and maintained, are an effective means of increasing trout production and, hence, yields to fishermen (Hunt 1971, 1976; White and Brynildson 1967). Installation and maintenance of stream structures, however, can be expensive and, if not well planned, can be short lived, ineffective, and cause further stream damage (Calhoun 1966; Colorado Division of Wildlife 1976; Ehlers 1956; Maughan et al. 1978). Effective trout stream improvement efforts involve two essential steps: an objective evaluation of structural needs of the habitat and design of structures to meet the hydrological features of the stream. There are a number of papers that describe structural designs that create desirable stream habitat features (U.S. Forest Service 1969; Pennsylvania Fish Commission ND; White and Brynildson 1967). The purpose of this paper is: 1) to present an objective, quantifiable method of evaluating trout streams in order to identify habitat deficiencies; and 2) to provide guidance in the design and installation of hydraulically-sound stream improvement structures.

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About 48 percent of the area of 11 western states is under federal control and management. The great majority of this land (80 percent) is being affected by domestic livestock grazing, logging, and mining. The vast majority of our self-sustaining populations of western trouts inhabit streams located on these same federal lands. Recent Bureau of Land Management (BLM) studies have indicated that more than 30,000 km of streams on BLM lands are in a degraded (fair to poor) condition (U.S. Bureau of Land Management 1975). Many more thousands of kilometers of public streams located on Forest Service and state lands in both the eastern and western United States are in similar condition. The need for stream improvement projects will be with us throughout the forseeable future.

Optimal trout stream habitat is characterized by clear cold water, a rocky substrate, an approximate 1:1 pool-riffle ratio with areas of slow deep water, a relatively stable flow regime, well vegetated stream banks, and abundant instream cover. Marginal trout streams and streams debilitated by man's activities on the watershed may be deficient in one or more of the above stream features. Stream improvement projects are attempts to produce, restore, and maintain these essential trout habitat features.

The above stream features are produced and maintained by natural forces in all healthy trout streams. Recent studies have shown that these natural geomorphological, climatic, and hydraulic forces will quickly and effectively repair stream deterioration when proper riparian: stream protection and land-use management is practiced. The reestablishment of grasses and forbs as stream bank vegetative cover, stabilization of stream banks and water temperatures, transformation of intermittent to perennial flows, reduction of sediment loads, and restoration of rocky substrates, pools, and riffles can occur rapidly (within 3 to 5 years) with resulting three- to four- fold increases in trout standing crops (Duff 1978; Keller, et al. 1978; VanVelson 1978). All stream improvement projects should begin with improved land management practices that permit nature to make the initial repairs to the stream. Structural stream improvement projects should supplement not supplant proper land management practices. Stream improvement projects in the past have too often been expensive methods of treating symptoms rather than curing stream ills.

EVALUATION OF THE HABITAT

The U.S. Fish and Wildlife Service is developing an objective, quantifiable procedure to evaluate aquatic and terrestrial habitats on a biological basis. The trout stream habitat evaluation procedures we present are adapted from the U.S. Fish and Wildlife Service aquatic procedures.

The procedure is species oriented. Various stream habitat parameters such as cover, velocity, and substrate, receive a Parameter Suitability Index (PSI) score for trout species and life stages of interest. Pertinent habitat parameters are evaluated by use of suitability curves constructed by life stage for each species (fig. 1). Suitability curves that determine habitat parameter scores are based on the effect of each parameter on the growth, survival, or biomass at each life stage of the species. Information used for the construction of suitability curves was obtained from the technical literature, from the files of natural resource agencies, and from expert opinion. Parameter scores range from 0 to 1.0 based on the degree to which a particular habitat parameter meets the habitat requirements of trout (1.0 = optimum, 0 = no value).

The basic problem with the suitability index curve approach is that it treats each habitat parameter as if its effect was independent of other habitat parameters. This assumption of independence is admittedly not true. We have attempted to show some simple parameter interactions for example between temperature and dissolved oxygen and between substrate as cover and percent fines, but even these are inadequate. A response surface approach is needed, but the present available data base for trout would not sufficiently support this approach. The suitability index curve approach is presented as an objective, quantifiable, improved habitat evaluation method over existing more subjective methods.

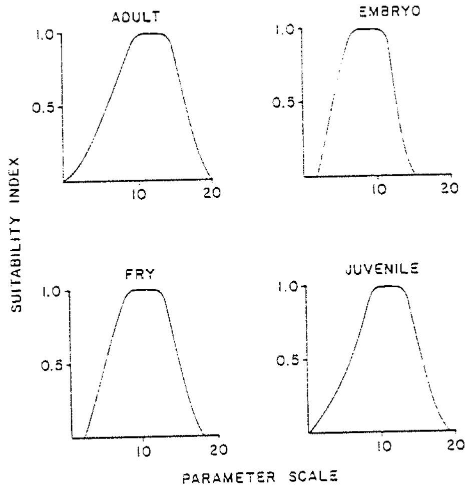


Figure 1.--Trout habitat suitability index curves by parameter and life stage.

Measurements of pertinent habitat parameters are obtained by sampling selected sites along the stream reach. It is usually best to evaluate the stream during late summer low flow when stream habitat conditions are poorest. Each parameter measurement is then assigned a suitability index score obtained from the appropriate suitability index curves as illustrated in Figure 2. The PSI scores can be arranged into a matrix to display the degree to which each habitat parameter meets the habitat requirements of each life stage of the species (Table 1). These PSI scores can now be compared to provide guidance in the selection of the kinds of stream modifications that are needed, e.g., shade, overhead cover, pools, spawning riffles, and others.

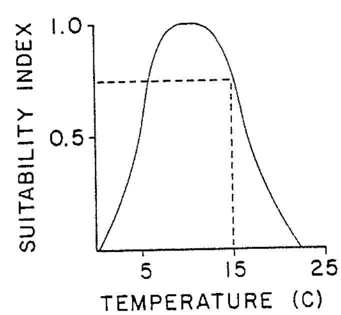


Figure 2.--Relationship between habitat measurement and suitability index score for trout.

Table 1.--Parameter suitability index scores by trout life stage.

Parameters	Adult	Embryo	Fry	Juvenile	All Stages
			Life Stage		
Temperature	0.8	0.6	0.8	0.8	--
Dissolved O_2	1.0	1.0	1.0	1.0	--
Substrate	--	0.3	Winter Cover 0.4	0.3	Invert. Prod. 0.4
Velocity/Depth (Feeding Station)	0.5	Incubation 1.0	0.7	0.8	--
Velocity/Visibility (Cover)	0.3	--	Escape Cover 0.5	0.4	--
Pool/Riffle Ratio	--	--	--	--	0.4
Stream Shade (Percent)	--	--	--	--	0.7
Riparian Vegetation (Percent)	--	--	--	--	0.3

The suitability curves presented below are generalized trout curves. We originally intended to construct specific life stage curves for each trout species. Certainly, the habitat requirements of cutthroat trout (Salmo clarki) differ considerably from those of rainbow (S. gairdneri) or brown trout (S. trutta). In addition, we were aware that the response of brook trout (Salvelinus fontinalis) to certain habitat parameters in an Appalachian Mountain stream differ in degree from the response of brook trout in a low gradient Wisconsin prairie stream. Indeed, some of these regional differences have been documented in various studies. However, the existing data base for trout was insufficient to support a complete set of curves with ranges and optimum values for all parameters and all life stages, for even a single species of trout. Thus, except for temperature requirements, we have combined data for all trout species into a single set of general "trout" habitat suitability curves. Trout habitat requirement information supported by several studies is plotted as a solid line on the suitability index curve graphs. Portions of the curves constructed from less precise data, general statements or "expert" opinion, are shown as broken lines. We believe the curves are generally correct, but urge users to construct more specific curves whenever a more precise data base is available. Pertinent habitat parameters for trout, and the data base from which our suitability curves were constructed, are discussed in the following sections.

Cover and Feeding Stations

Trout literature does not often clearly distinguish between feeding stations, escape cover and winter cover requirements. Prime requisites for optimum feeding stations appear to be low water velocity and access to a plentiful food supply e.g., energy accretion at a low energy cost. Water depth appears to be a less well defined selection factor and the presence of overhead cover (shade, water surface turbulence, overhanging banks and vegetation) is preferred but not essential. Escape cover must be nearby. Griffith (1972) states that younger trout live in shallower water and stay closer to escape cover than older trout. Agonistic behavior and hierarchies are established at feeding stations, but trout will often share escape cover. Deeper water areas are more often utilized as escape cover than as preferred feeding areas.

The feeding stations of dominant trout usually include cover if available. The feeding stations of subdominant adults and juvenile trout often does not include adequate cover.

The suitability curves for velocity and depth in figures 3, 4, and 5 can be used to evaluate a stream reach for adequate feeding station and cover habitat. A total of 50 percent of the stream reach area is considered adequate feeding station area to support an average trout population. Include cover area estimates calculated below, as part of the total feeding station area estimate. Generally, a 40 to 60 percent pool:riffle ratio will provide adequate feeding station habitat.

Several studies have demonstrated the importance of cover to salmonid populations. Some studies have suggested that cover features may indeed determine carrying capacities of salmonids (Bohlin 1978; Kalleberg 1958; White 1978). Bustard and Narver (1975a) state that very few salmonids are found in stream areas lacking cover. Salmonids use instream structures, substrate, deep water, overhanging vegetation, and undercut banks for cover. A major advantage of summer cover is probably that it offers protection from predators. Also, cover provides resting areas and may help prevent downstream displacement during periods of high water velocity.

In some streams a major factor limiting salmonid densities may be the amount of adequate overwintering habitat rather than summer rearing habitat (Bustard and Narver 1975a). Everest (1969) suggested that some salmonid population levels were regulated by the availability of suitable hibernating areas. The major advantages in seeking winter cover are: prevention of physical damage from ice scouring (Chapman and Bjornn 1969; Hartman 1965) and conservation of energy (Chapman and Bjornn 1969; Everest 1969). Winter hiding behavior in salmonids is triggered by low temperatures (Bustard and Narver 1975a,b; Chapman and Bjornn 1969; Everest 1969). Bustard and Narver (1975a) indicated that as water temperatures dropped to 4 to 8° C feeding was reduced in young salmonids and most were found within or near cover; few were found more than 1 m from potential cover.

Cutthroat trout were found under boulders, log jams, upturned roots, and debris when temperatures neared 4 to 8° C, depending on velocity (Bustard and Narver 1975a). Bjornn (1971) observed that nearly all the rainbow trout in his study lived in or near rock piles during the winter. Lewis (1969) reported that adult rainbow trout tended to move into deeper water during winter. Bustard and Narver (1975a) also reported that the streambank environment was very important to overwintering steelhead trout. Evaluation of a stream reach for adequate cover must consider the specific cover requirements of a species by season of the year and by life stage.

Cover for adult Trout

Cover for adult trout consists of areas of low stream bottom visibility; the stream bottom must be indistinct or obscured to the viewer and must be in areas of low current velocity ($\leq$20 cm/sec). A minimum cover area of 25 percent of the stream reach appears to be required to support an average adult trout population. Adult trout appear to utilize similar cover features at all seasons of the year but tend to occupy deeper slower water during the winter.

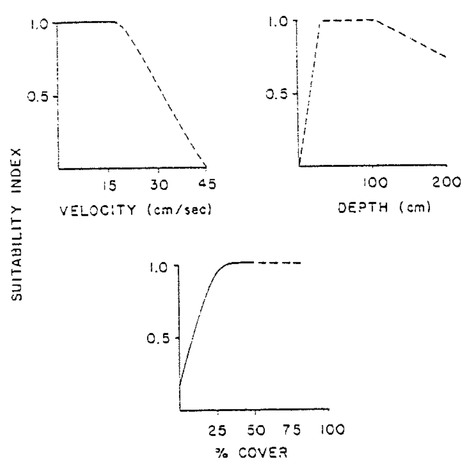


Figure 3.--Velocity. depth and cover suitability curves for adult trout feeding stations and cover.

A suitability index score for adult trout cover can be obtained by measuring amounts of stream area having low or obscure stream bottom visibility and water velocities of 20 cm/sec or less. Divide the area figure by the total area of the stream reach and multiply by 100. This percentage figure is entered on the X axis of the appropriate suitability curve (fig. 3). The PSI score is obtained from the Y axis.

Cover for Trout fry

Trout fry remain in the gravel for about 2 weeks after hatching (Scott and Crossman 1973) and depending on water temperature, emerge from the gravel 45 to 75 days after egg fertilization (Calhoun 1944; Lea 1968). Trout fry of stream spawners exhibit three distinctly different genetically controlled patterns when moving from natal gravels to rearing areas: 1) Movement downstream to a larger river or lake; 2) movement upstream from an outlet river to a lake; or 3) local dispersion within a common spawning and rearing area to areas of low velocity and cover (Raleigh and Chapman 1971). Fry residing in stream environments prefer shallower water and slower velocities than other life stages (Horner and Bjornn 1976; Miller 1957). Velocities of less than 30 cm/sec are utilized with less than 8.0 cm/sec optimum (Horner and Bjornn 1976).

Fry survival decreases with increased velocities after some optimal velocity has been reached (Bulkley and Benson 1962: Drummond and McKinney 1965). Trout fry typically are found occupying backwater pool areas or the low velocity areas of pools along the stream edges. The shallow water offers some protection from large predators but escape cover in the form of aquatic vegetation, debris piles, and the interstitial spaces between rocks is critical. As these young trout mature they move to deeper, faster water. Everest (1969) suggested that one reason for this movement was the need for cover which is fulfilled by increased water depth, turbulence, and larger substrate.

Trout fry usually overwinter in the principally rubble substrate in shallow water of low velocity near the stream margin (Bustard and Narver 1975a). Optimum size of substrate used as winter cover for trout fry ranges from 20 to 40 cm in diameter (Everest 1969; Hartman 1965). Chapman and Bjornn (1969) demonstrated that trout fry entered the rubble bottom in response to decreasing temperature. None were observed above the substrate when water temperatures fell below 4° C. Stream siltation is the major factor in the loss of winter cover for juveniles. Figure 4 contains parameter suitability index curves to evaluate a stream reach for adequate fry cover. Both the velocity and substrate curves should be used. A total area of about

10 percent of the stream reach is needed as fry rearing area.

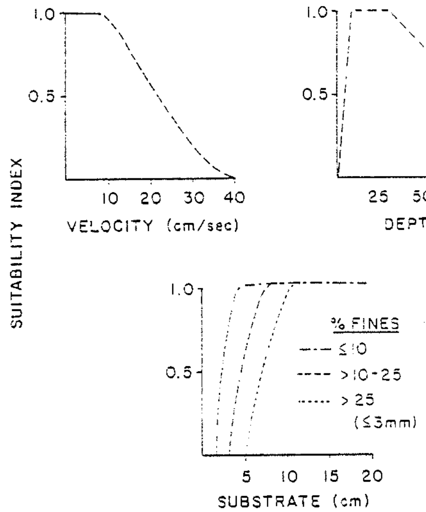


Figure 4.--Velocity, depth, and substrate suitability index curves for trout fry feeding stations and cover.

Cover for juvenile Trout

Bustard and Narver (1975b) demonstrated thatjuvenile cutthroat trout used rubble and overhanging banks as cover. When given a choice between areas containing overhanging bank cover and areas without cover the cutthroat choose the overhanging bank cover areas. Cutthroat trout also showed a preference for clean rubble as opposed to areas of silted rubble for cover. Common types of cover for juvenile trout are upturned roots, logs, debris piles, overhanging banks, and boulders. Bustard and Narver (1975a) also reported that young salmonids occupy different habitats in the winter than in the summer. Log jams and rubble appear to be the most important winter cover.

Edmundson et al. (1968) reported that juvenile steelhead (Salmo gairdneri) were primarily under or between rubble particles in the winter. Everest (1969) demonstrated that juvenile steelhead actively seek suitable overwintering areas in the fall and they began entering the substrate when temperatures fell below 7° C. No juvenile steelhead were found above the substrate when temperatures reached 5° C. These fish were found 15 to 30 cm deep in the substrate which was often covered by 5 to 10 cm of anchor ice. Everest (1969) indicated that juvenile steelhead do not feed during winter hibernation and after entering the substrate they do not come out until the water temperature rises above 7° C.

Parameter suitability index curves to evaluate a stream reach for adequate juvenile trout cover are located in Figure 5. The water velocity and depth curves should be used to evaluate for feeding stations and the cover curve to obtain escape and winter cover index scores.

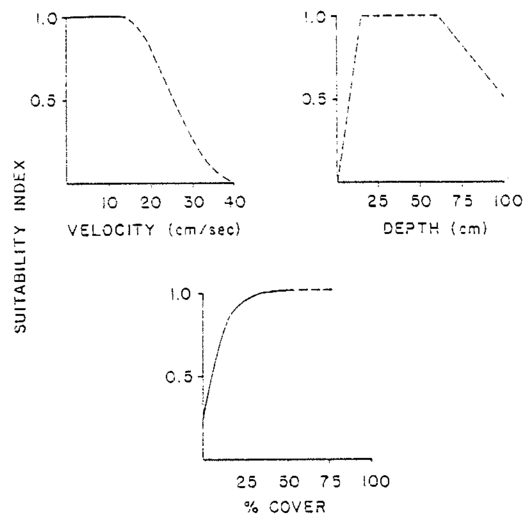


Figure 5.--Velocity, depth, and cover suitability index curves for trout juveniles feeding stations and cover.

Temperature and Oxygen

Dissolved oxygen requirements vary with the the species, age of fish, prior acclimation temperature, water velocity, and concentration of substances in the water (McKee and Wolf 1963). As temperatures increase the dissolved oxygen level in the water decreases while the dissolved oxygen requirement for the fish increases. As a result, an increase in temperature resulting in a decrease in dissolved oxygen can be detrimental to the fish. Doudoroff and Shumway (1970) demonstrated that swimming speed and growth rates for salmonids declined with decreasing dissolved oxygen levels. Cutthroat trout generally avoid water with a dissolved oxygen level of less than 5 mg/l in the summer (Sekulich 1974; Trojnar 1972).

With the exception of redband trout, a probable subspecies of rainbow, trout usually do not persist in waters where maximum temperatures consistently exceed 22° C, although they may be able to withstand brief periods of daytime water temperature as high as 26° C (Behnke in press). Bell (1973) reported a preferred temperature of 9 to 12° for cutthroat trout, Garside and Tait (1958) 12 to 14° for rainbow trout, and Ferguson (1958) 12 to 18° for brown trout. Needham and Jones (1959) reported adult trout will actively feed at a temperature of 0° C.

The oxygen and temperature requirements of adult and juvenile trout appear to be similar. The suitability curves for evaluation of oxygen and temperature requirements of trout are in Figure 6. The average summer seasonal value or an estimate thereof should be used to obtain PSI scores for oxygen and temperature. If parameter values are beyond the upper limits for temperature for more than 72 hours, or the lower limits for oxygen for more than 48 hours during the season, the PSI score would be zero.

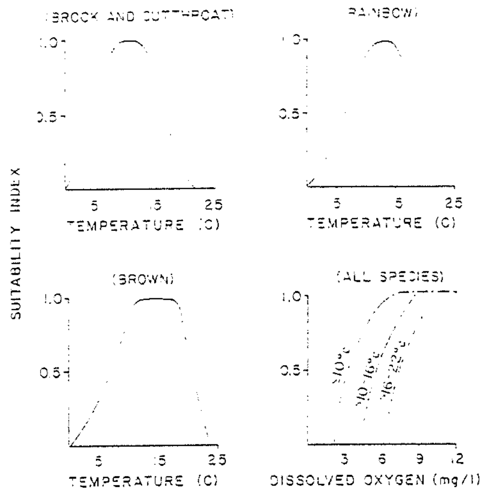


Figure 6.--Temperature and oxygen suitability index curves for Brook, Brown, Cutthroat, and Rainbow Trout (All life stages except embryo).

Spawning Requirements

Reproductive Behavior

Most trout are stream spawners. The fertilized ova are deposited in redds constructed primarily by the female in the stream gravels (Smith 1941, 1947). Populations of salmonids residing in lakes may spawn in both outlet and inlet streams (Raleigh 1971; Raleigh and Chapman 1971).

Spawning of cutthroat and rainbow trout begins as early as March (Behnke and Zarn 1976; Fleener 1951) and as late as August (Fleener 1951; Juday 1907). Spawning of brook and brown trout begins as early as October and can extend into January and February (Brasch et al. 1958; Munro and Balmain 1956). The time of spawning depends on water temperature, runoff (Lea 1968), ice melt (Calhoun 1944), elevation, and latitude (Behnke and Zarn 1976). Post-spawning mortality of adults is high in most populations (Carlander 1969; Irving 1954; Scott and Crossman 1973).

Embryo

The length of the incubation time varies with temperature. Eggs of spring and summer spawners usually hatch within 28 to 40 days (Cope 1957), but may take as long as 49 days (Scott and Crossman 1973). Eggs of fall spawners overwinter in the gravel and hatch in the early spring. The optimum temperature for incubation is approximately 10° C (MacCrimmon and Campbell 1969; Snyder and Tanner 1960). The combined effects of temperature, dissolved oxygen levels, water velocity, and gravel permeability are important for successful incubation. Suitable incubation substrate is gravel 3 to 80 mm in diameter (Duff 1977; Stuart 1953). The maximum gravel size preferred depends on the size of the spawning female.

Suspended sediment levels greater than 130 ppm, combined with dissolved oxygen concentrations less than 6.9 mg/l and velocities in the redd of less than 55 cm/hr, can reduce egg survival to below 10 percent (Bianchi 1963). Coble (1961), working with steelhead trout embryos, demonstrated that velocities and dissolved oxygen concentrations were closely related in their effect on embryo survival. Doudoroff and Shumway (1970) reported that salmonids that hatched at low dissolved oxygen levels were weak and small; their development was slower and there were abnormalities. Figure 7 contains suitability index curves to evaluate embryo habitat requirements. Use the 15 percent of the substrate area having the best combination of velocity, temperature, dissolved oxygen and substrate size for evaluation.

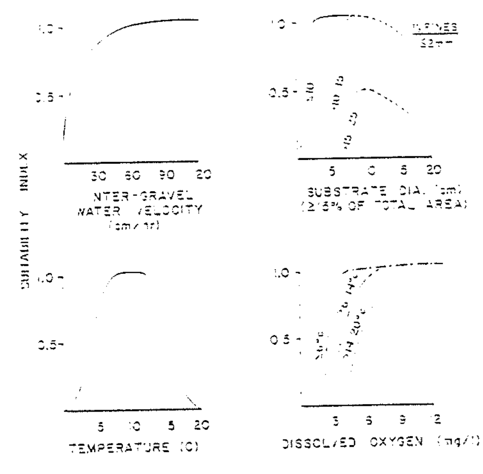


Figure 7.--Habitat suitability index curves for trout embryo development and survival.

Other Important Trout Habitat Parameters

Headwater trout streams tend to be relatively unproductive. Most energy inputs to the streams are in the form of allochthonous materials: leaves, other terrestrial vegetation, and terrestrial insects. Thus, streamside vegetation is important not only to reduce bank erosion and stabilize water temperatures but also as an energy source to the aquatic food chain. About 40 to 50 percent or more of the food eaten by trout in headwater streams during the summer is made up of terrestrial insects.

The presence of aquatic vegetation and a mosaic of substrate types increases the diversity of invertebrate fauna, but aquatic invertebrates are most abundant on rubble substrate in stream riffle areas (Hynes 1970). Rubble supports more invertebrates than other substrate types because its size and irregular shape provides a nearly optimum ratio of stable living space. Aquatic vegetation is also an excellent invertebrate substrate material. In several studies, vegetated areas were more heavily colonized than nonvegetated areas of substrate (Hynes 1970). In general, sand is the poorest habitat for invertebrate production. Even on stony substrate the presence of silt reduces and changes the invertebrate fauna. A ratio of about 1:1 pool to riffle area appears to be the best overall trout stream habitat (Needham 1940). This pool:riffle ratio appears to provide an optimum mix of trout rearing areas and substrate for invertebrate production.

Canopy cover is important in maintaining shade for stream temperature control and to provide allochthonous materials to the stream. Too much shade can, however, restrict primary productivity in streams. Shading becomes increasingly important at lower, warmer elevations and as stream gradients decrease. In humid areas shade is important, but the stream canopy cover must be open to permit good air circulation and to promote cooling by evaporation. Riparian vegetation helps to stabilize the bank and control erosion as well as provide allochthonous inputs to the stream. In most streams, overhanging stream banks do not persist in streams with less than a 60 percent vegetative bank cover.

PSI curves to evaluate these important trout stream habitat parameters are located in Figures 8 and 9.

HYDROLOGY CONSIDERATIONS

The application of stream hydrogeomorphic principles can reduce the failure so prevalent with past stream improvement projects. Ideally, fishery biologists should be part of an interdisciplinary team with hydrology and engineering specialists. This team effort will help to assure that proper biological and physical aquatic-riparian habitat characteristics are considered. Instream structures should be given individual site specific design because each stream is different in habitat conditions, landform, and stream water energy flow.

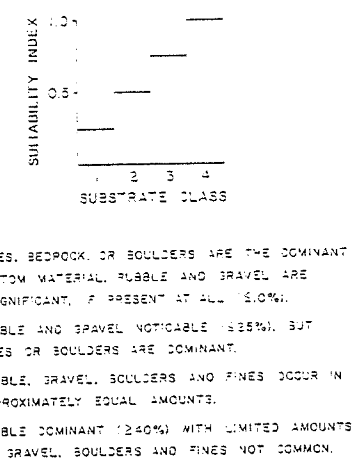


Figure 8.--Trout habitat suitability index values for substrate size as a measure of invertebrate production.

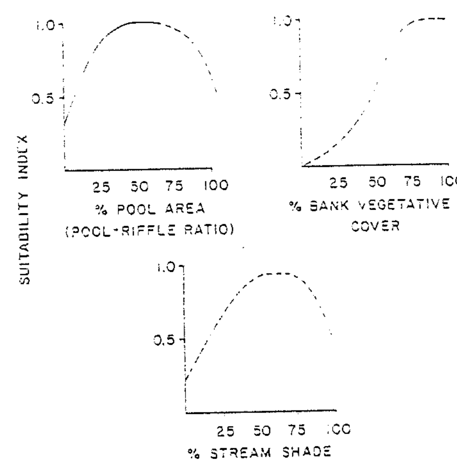


Figure 9.--Trout habitat suitability index curves for percent pools, bank vegetation cover and shade.

A great portion of western trout streams have moderate to steep gradients that are subject to high runoff during spring snow melt and summer storm events. This flooding offers the greatest challenge to the successful operation and maintenance of instream structures, i.e., log dams (single and multiple log), gabions, and trash catchers.

Some technical points that should be considered in the placement and design of instream habitat improvement structures are: stream channel gradient and annual water discharge regime (maximum and minimum flows); width and depth of stream; stream bank soil class, composition, and stability; and stream bottom composition. In describing stream channel flow patterns hydrologists use the general terms of meandering, braided, and straight. Natural streams are seldom straight for any great distance. Even a recently channelized stream quickly begins to form a meander pattern within its altered channel. A stream takes on a typical meander shape, mathematically described as a "sine-generated curve". The path of this kind of curve requires water to do the least work and therefore is the path most likely to be followed (Leopold and Langbein 1966).

Meander bends are the areas of greatest bank movement. Instream structures should never be in close proximity to meander bends because the water energy flow could cause excessive streambank cutting and erosion which result from one-sided flows over instream structures located at bends in the stream. Instream structures in these locations are more prone to end cutting and wash out than in the straighter stream sections between meanders. A good rule to follow in placing instream structures is to locate them in relatively straight channel reaches, with generally stable banks, and low to moderate gradients. We have found that the utilization of channel reaches with a low coefficient of roughness, will carry water over the structure during low as well as high flows, and will enhance operation and maintenance success of the structure.

Each stream channel carries its own energy flow from its annual discharge. The energy generated is a function of the stream's gradient, channel characteristics, and habitat condition. The channel form will vary markedly depending upon the character of the bank material. When the stream banks are resistent to erosion, the stream tends to dig a deeper, narrower channel (Leopold et al. 1964). Streams with a firm substrate and erodable banks tend to abrade during periods of high water. The stream's energy can be used, in conjunction with well designed and placed instream structures, to dig pools and move stream bed load material. The structures should be spaced to provide pool: riffle ratios characteristic of quality trout streams.

Ideally, structures should be placed in straight stream sections with low to moderate gradient and at least moderately well developed, stable banks where high water flows will create the least problem. Stream bank stabilization work should be done in conjuction with placement of instream structures in areas with poorly developed or erodable banks that are prone to end cutting by periodic high water flows. The instream structure should be located in the channel perpendicular to each bank and set on the stream bottom so there will be constant flow over all portions of the log. A continuously submerged log will last longer and be less subject to the deterioration from rot caused by wetting and drying during periodic high and low flows. A notch cut in the center-top of the log will direct a portion of the flow to dig and maintain a pool even during periods of low flow. Straight logs 23-30 cm. in diameter are best in most small western trout waters. Of course, log size will vary according to the stream width, depth, gradient, and discharge. We advocate the use of log dam structures because of their natural appearance, low cost, and ease of construction compared to more artificial structures such as trash catchers and gabions. We also advocate the planting of native vegetation and use of rocks and logs, to stabilize banks, rather than gabions, cement or other more artificial materials. Construction should be planned for the summer-fall period of low flows when trout habitat is most limited, since the habitat problems are most obvious and construction problems are minimal at this time of year.

Water flowing over log dams should fall into the downstream pool at nearly a 90 degree angle from the flow over the log. This angle will usually provide a plunge-pool depth at least 1.25 times the distance from the crest of the waterfall to the water level of the pool. This angle will also create a standing wave situated close to the waterfall; an optimum position for trout to use in leaping over the log dam for upstream movement. During the 1977 drought in Utah, BLM stream studies documented that low discharges did not always flow over gabion and trash catcher structures, but were flowing through the structures and thereby creating a barrier to fish movement. Summer low water flows over well-built log structures, however, continued to provide adequate water for upstream movement.

Structures placed on soft substrates will encourage the stream to tunnel under the structure. High water velocities increase this tendancy. Try to select areas with a firm, stable stream bottom or plan to strengthen and stabilize the stream bottom in the area of the structure. Always anchor stream barrier structures well into the bank. Quiet water areas will be created upstream and downstream from barrier structures and these quiet areas will eventually collect sand and silt. Avoid silting valuable invertebrate habitat or fish spawning areas. Stream narrowing structures can be used to flush excess sand and silt from a stream.

A thorough understanding of the watershed condition and management is needed to predict success of stream habitat improvements. There is little value in attempting to improve streams where activities such as over-grazing by livestock, poor logging, road building, and farming activities will continue. Studies in Utah by the BLM have shown that little benefit is derived from stream improvement structures placed in areas continually overgrazed by livestock or otherwise mismanaged. Only in stream areas adequately protected from livestock overgrazing did instream structures remain operationally efficient and in place (Duff 1977). Utilization of the principles of hydrology and geomorphology in planning and construction of instream improvement structures will enhance an aquatic habitat improvement project and can determine the success or failure of a project. In a time when our valuable aquatic-riparian habitats and wild trout populations are dwindling the application of correct ecological and hydrological principles in stream improvement projects can enhance our attempts to maintain viable trout populations and habitats.

LITERATURE CITED

Behnke, R.J. In press. Monograph of the native trouts of the genus Salmo of western North America. Rept. prepared for U.S. Dept. Int., Fish and Wildl. Serv., Denver.

__________, and M. Zarn. 1976. Biology and management of threatened and endangered western trout. U.S.D.A. For. Serv. Gen. Tech. Rep. RM-28.45 pp.

Bell, M.C. 1973. Fisheries handbook of engineering requirements and biological criteria. U.S. Army Corps Eng. North Pacific Div. Contract DACW57-68-C-0086. 92 pp.

Bianchi, D.R. 1963. The effects of sedimentation on egg survival of rainbow trout and cutthroat trout. M.S. thesis, Montana State Coll., Bozeman. 28 pp.

Binns, N.A., and F.M. Eiserman. 1976. Environmental index of trout streams. Job no. 7075-01-7101. Administrative Files, Wyoming Dept. Fish Game, Cheyenne. 10 pp.

Bjornn, T.C. 1971. Trout and salmon movements in two Idaho streams as related to temperature, food, streamflow, cover, and population density. Trans. Am. Fish. Soc. 100(3):423-438.

Bohlin, T. 1978. Temporal changes in the spatial distribution of juvenile sea-trout (Salmo trutta) in a small stream. Oikos 30(1): 114-120.

Brasch, J., J. Mcfadden, and S. Kmiotek. 1958. Brook trout. Life history, ecology and management. Wisc. Dept. Nat. Res. Pub. 226. 15 pp.

Bulkley, R.V., and N.G. Benson. 1962. Predicting year-class abundance of Yellowstone Lake cutthroat trout. U.S.D.I. Fish and Wildl. Res. Rep. 59. 21 pp.

Bustard, D.R., and D.W. Narver. 1975a. Aspects of the winter ecology of juvenile coho salmon (Oncorhynchus kisutch) and steelhead trout (Salmo gairdneri). J. Fish. Res. Board Can. 32(3):667-680.

__________. 1975b. Preferences of juvenile coho salmon (Oncorhynchus kisutch) and cutthroat trout (Salmo clarki) relative to simulated alternation of winter habitat. J. Fish. Res. Board Can. 32(3):681-687.

Calhoun, A.J. 1944. The food of the black-spotted trout in two Sierra Nevada lakes. California Fish Game 30(2):80-85.

__________. 1966. Habitat protection and improvement. Pages 40-48 in A.J. Calhoun (ed.) Inland Fisheries Management. State of California, Dept. Fish and Game.

Carlander, K.D. 1969. Handbook of freshwater fishery biology. Iowa State Univ. Press, Ames. Vol. I 752 pp.

Chapman, D.W., and T.C. Bjornn. 1969. Distribution of salmonids in streams, with special reference to food and feeding. Pages 153-176 in T.G. Northcote (ed.) Symposium on Salmon and Trout in Streams, H.R. MacMillan Lectures in Fisheries, Univ. British Columbia, Vancouver.

Coble, D.W. 1961. Influence of water exchange and dissolved oxygen in redds on survival of steelhead trout embryos. Trans. Am. Fish. Soc. 90(3):469-474.

Colorado Division of Wildlife. 1976. Stream improvement analysis. Mimeo rept.,

Cope, O.B. 1957. The choice of spawning sites by cutthroat trout. Proc. Utah Acad. Sci., Arts, and Letters 34:73-79.

Doudoroff, P., and D.L. Shumway. 1970. Dissolved oxygen requirements of freshwater fishes. Food and Agriculture Organization of the United Nations Fish. Tech. Paper 86. Rome. 291 pp.

Drummond, R.A., and T.D. McKinney. 1965. Predicting the recruitment of cutthroat trout fry in Trappers Lake, Colorado. Trans. Am. Fish. Soc. 94(4):389-393.

Duff, D.A. 1977. Livestock grazing impacts on aquatic habitat in Big Creek, Utah. In Press In Symposium Livestock Interactions with Wildlife, Fisheries, and their Environments. U.S.D.A., Forest Service Pac. S.W. Exp. Sta., Sparks, Nevada. 35 pp.

__________. 1978. Riparian habitat recovery on Big Creek, Rich County, Utah - a summary of 8 years of study. Pages 91-92 in O.B. Cope (ed.) Forum - Grazing and Riparian/Stream Ecosystems (Nov. 3-4, 1978). Trout Unlimited, Inc., March 1979.

Edmundson, E., F. Everest, and D.W. Chapman. 1968. Permanence of station in juvenile chinook salmon and steelhead trout. J. Fish. Res. Board Can. 25(7):1453-1464.

Ehlers, R. 1956. An evaluation of stream improvement devices constructed eighteen years ago. Calif. Fish and Game 42(3): 203-217.

Everest, F.H. 1969. Habitat selection and spatial interaction of juvenile chinook salmon and steelhead trout in two Idaho streams. Ph.D. Diss., Univ. Idaho, Moscow. 77 pp.

Ferguson, R.G. 1958. The preferred temperature of fish and their mid-summer distribution in temperate lakes and streams. J. Fish. Res. Board Can. 15:607-624.

Fleener, G.C. 1951. Life history of the cutthroat trout, Salmo clarki, in Logan River, Utah. Trans. Am. Fish. Soc. 81(2): 235-248.

Garside, E.T. and J.S. Tait. 1958. Preferred temperature of rainbow trout (Salmo gairdneri Richardson) and its unusual relationship to acclimation temperature. Canadian J. Zool. 36:563-567.

Griffith, J.S. Jr. 1972. Comparative behavior and habitat utilization of brook trout (Salvelinus fontinalis) and cutthroat trout (Salmo clarki) in a small stream in northern Idaho. J. Fish. Res. Board Can. 29(3):265-273.

Hartman, G.F. 1965. The role of behavior in the ecology and interaction of underyearling coho salmon (Oncorhynchus kisutch) and steelhead trout (Salmo gairdneri). J. Fish. Res. Board Can. 22:1035-1081.

Horner, N., and T.C. Bjornn. 1976. Survival, behavior, and density of trout and salmon fry in streams. Univ. of Idaho, For., Wildl. and Exp. Stn., Contract 56, Prog. Rep. 1975. 38 pp.

Hunt, R.L. 1971. Responses of a brook trout population to habitat development in Lawrence Creek. Tech. Bull. 48. Dept. Nat. Res., Madison, Wisc. 35 pp.

_________. 1976. A long-term evaluation of trout habitat development and its relation to improving management-related research. Trans. Am. Fish. Soc. 105(3): 361-364.

Hynes, H.B.N. 1970. The ecology of running waters. Univ. Toronto Press, Canada. 555 pp.

Irving, R.B. 1954. Ecology of the cutthroat trout in Henry's Lake, Idaho. Trans. Am. Fish. Soc. 84(2):275-296.

Juday, C. 1907. Notes on Lake Tahoe, its trout and trout fishing. Bull. U.S. Bur. Sport Fish. 26:133-146.

Kalleberg, H. 1958. Observations in a stream tank of territoriality and competition in juvenile salmon and trout (Salmo salar L. and Salmo trutta L.). Inst. Freshwater Res. Drottningholm 39:55-98.

Keller, C., L. Anderson, and P. Tappel. 1979. Fish habitat changes in Summit Creek Idaho, after fencing in the riparian area. pp. 46-52. In Cope, O.B. (ed.) Proc. Forum - Grazing and Riparian/ Stream Ecosystems. Denver, Colo., 1978. Trout Unlimited.

Lea, R.N. 1968. Ecology of the Lahontan cutthroat trout, Salmo clarki henshawi, in Independence Lake, California. M.A. thesis, Univ. Calif., Berkeley. 95 pp.

Leopold, L.B., and W.B. Langbein. 1966. River meanders. Scient. Am. 214:60-70.

___________, M.G. Wolman, and J.P. Miller. 1964. Fluvial Processes in Geomorphology. Freeman, San Francisco.

Lewis, S.L. 1969. Physical factors influencing fish populations in pools of a trout stream. Trans. Am. Fish. Soc. 98(1):14-19.

MacCrimmon, H.R., and J.C. Campbell. 1969. World distribution of brook trout, Salvelinus fontinalis. J. Fish. Res. Board Can. 26:1699-1725.

Maughn, D.E., K.L. Nelson, and J.J. Ney. 1978. Evaluation of stream improvement practices in southeastern trout streams. Virginia Water Resources Research Center Bull. 115. Virginia Polytechnic Inst. and State Univ., Blacksburg. 67 pp.

McKee, J.E., and H.W. Wolf. 1963. Water quality criteria. State Water Quality Control Board. Sacramento, Calif. Pub. 3A. 548 pp.

Miller, R.B. 1957. Permanence and size of home territory in stream-dwelling cutthroat trout. J. Fish. Res. Board Can. 14(5): 687-691.

Munro, W.R., and K.H. Balmain. 1956. Observations on the spawning runs of brown trout in South Queich, Loch Leven. Freshw. Salm. Fish. Res. Scot., 13.17 pp.

Needham, P.R. 1940. Trout streams. Comstock Publi. Co., Inc., Ithaca, N.Y. 233 pp.

___________, and A.C. Jones. 1959. Flow, temperature, solar radiation, and ice in relation to activities of fishes in Sagehen Creek, California. Ecology 40(3):465-474.

Pennsylvania Fish Commission. ND. Stream habitat improvement. Penns. Fish Comm. 21 pp.

Raleigh, R.F. 1971. Innate control of migrations of salmon and trout fry from natal gravels to rearing areas. Ecology 52(2): 291-297.

___________, and D.W. Chapman. 1971. Genetic control in lakeward migrations of cutthroat trout fry. Trans. Am. Fish. Soc. 100(1): 33-40.

Scott, W.B., and E.J. Crossman. 1973. Freshwater fishes of Canada. Fish. Res. Board Can. Bull. 184. 966 pp.

Sekulich, P.T. 1974. Role of the Snake River cutthroat trout (Salmo clarki subsp.) in fishery management. M.S. thesis. Colo. St. Univ., Ft. Collins. 102 pp.

Smith, O.R. 1941. The spawning habits of cutthroat and eastern brook trouts. Trans. Am. Fish. Soc. 5(4):461-471.

__________. 1947. Returns from natural spawning of cutthroat trout and eastern brook trout. Trans. Am. Fish. Soc. 74:281-296. (1944).

Snyder, G.R., and H.A. Tanner. 1960. Cutthroat trout reproduction in the inlets to Trappers Lake. Colo. Fish Game Tech. Bull. 7. 85 pp.

Stuart, T.A. 1953. Spawning migration, reproduction and young stages of loch trout. Scottish Home Dept., Fresh, and Salmon Fish Res. 5. 39 pp.

Trojnar, J.R. 1972. Ecological evaluation of two sympatric strains of cutthroat trout. M.S. thesis. Colo. St. Univ., Ft. Collins. 59 pp.

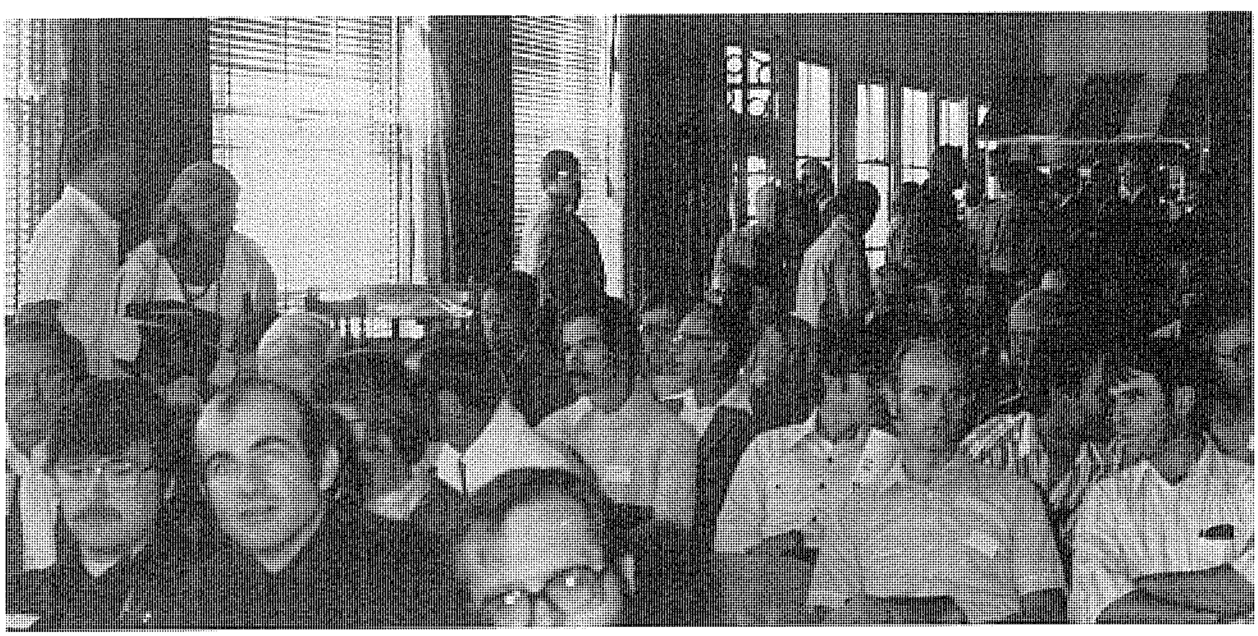
U.S. Forest Service. 1969. Wildlife habitat improvement handbook. Cat. no. FSH 2609.11, August 1969.

U.S. Bureau of Land Management. 1975. Range condition report prepared for the Senate Committee on Appropriations. U.S.D.I., Bur. Land Manage. VII-E. 6 pp.

VanVelson, R. 1979. Effects of livestock grazing upon rainbow trout in Otter Creek, Nebraska. pp. 53-55. In O.B. Cope (ed.), Proc. Forum - Grazing and Riparian/Stream Ecosystems. Denver, Colo., 1978. Trout Unlimited.

White, R.J. 1972. Trout population responses to habitat change in Big Roche-a-Cri Creek, Wisconsin. Ph.D. diss. Univ. Wisc., Madison. 296 pp.

__________, and O.M. Brynildson. 1967. Guidelines for management of trout stream habitat in Wisconsin. Dept. Nat. Resour., Div. of Conserv., Tech. Bull. 39. 65 pp.



MANAGEMENT PANEL

Discussion Leader

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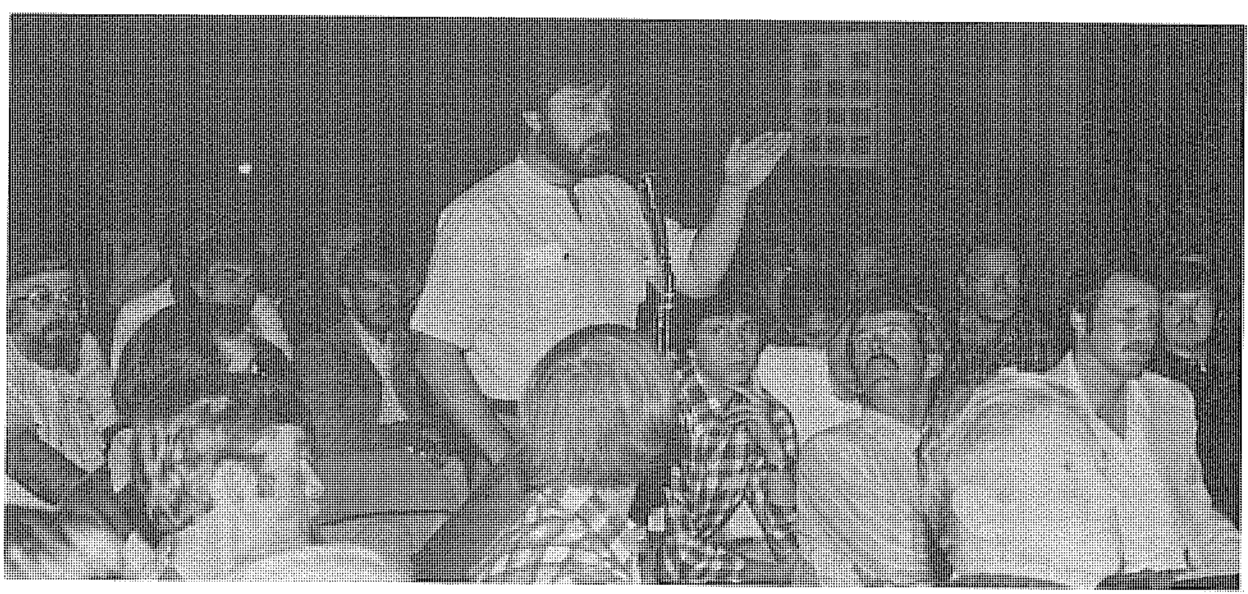
Introduction: Habitat preservation and wild trout management cannot be readily separated. Certainly the latter depends upon the former. "Management" to many people, even to biologists, is a rather loose word. Just about everything in this world is managed, for better or for worse. To manage a natural species, we are all aware that we must have the benefits from research as some of our sharpest tools; the environment must be suitable and its future secure; and the using public--the sport angler and the conservationist (they can be one and the same)--must be aware of these relationships that are intricately and inevitably involved.

In this panel, our thinking is directed to management as related to wild trout. The papers are offered primarily on a geographic basis--Alaska, Montana, the Columbia River Basin (Washington, Oregon, Idaho), the northeast coast bordering the Atlantic, and the Pacific coast of British Columbia. Several species are involved, both resident and anadromous, some in critical situations. The subject could be expanded ad infinitum, but only highlights can be treated here. The conclusion seems inevitable, that responsibility for management must be shared, no single agency of government can do an adequate job; nor can the same management philosophy or procedures serve equally well for all species or all waters. Management must be alert, responsive, imaginative, well informed, and responsible. It must be ready and willing to employ all available skills to accomplish its objectives. Needless to say, these objectives must be spelled out clearly and accepted by those who implement them.



WILD TROUT FISHING OPPORTUNITIES IN ALASKA

CONCEPTS AND OPTIONS FOR FUTURE MANAGEMENT[1]

Rupert E. Andrews[2]

Abstract.--The management of wild fisheries in Alaska is a high program priority. Included in the Alaskan concepts and objectives are the uniqueness of a species, the abundance of large-sized individual fish, and the opportunity for fishing experiences in a pristine environment. Quality fishery management is defined to include the needs of both anglers and angler habitat. Options for maintaining the present high levels of wild game fish abundance and limiting angler participation for truly wilderness trips are explored. Perhaps the most difficult challenge facing Alaskan fishery managers will be influencing land managers to accept limited development, and the user public to accept controlled numbers of people in remote wilderness watersheds.

Aldo Leopold, the conservationist, has said that in measuring the values of recreation we are so obsessed with the numbers who participate that we forget about the quality of the experience.

Alaska formally adopted the concept of wild trout management beginning in 1966, six years following statehood. During the ensuing years, the definition of what constituted quality wild trout fishing was continually refined to include a number of angler expectations as expressed to us in the Department of Fish and Game and to our regulatory commission, the Alaska Board of Fisheries. Quality fishery management is not limited to trout; all game fish species are included.

We also developed a parallel concept of wild trout quality management. The basic philosophical and management difference defined in quality wild trout management is simply that as much attention is given to the physical and spiritual conditions of angling as to naturally spawned trout.

Quite a lot of staff time and discussion has been spent with the angling public defining what was meant by wild trout and quality fishery management; what regulations would be required, what areas in Alaska would lend themselves to the definition, and what benefits would present and future anglers derive from fishery management that emphasized angler habitat as related to the quality of the fishing experience.

Recalling the first Wild Trout Symposium held in 1974 and listening to fishery managers and anglers from across the country, it was apparent that the quality of the fishing opportunity and experience was rated as high priority. Non-hatchery trout were considered an integral part of that fishing experience. Non-hatchery trout provided higher quality fishing experiences, as they were more vigorous opponents and could even provide a higher catch per unit of effort outside of urbanized areas.

ANGLER HABITAT

Let's examine the concept of angler habitat management. In 1974, Gardner Grant asked, "What will American trout anglers look for in the future?", and "What are you going to educate him to look for?" Gardner Grant, I believe, was principally speaking to fishery managers with his challenging questions. He also realized that fishery managers, in order to be effective, need an angling public who are aware of the many political problems confronting fishery managers and will provide needed support. Speaking as one fishery manager, I can tell you that more time is spent fighting political brush fires created by special interest groups and making political decisions than is spent on making biological decisions

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[1] Paper presented at the Wild Trout II Symposium, Yellowstone National Park, Wyoming, September 24-25, 1979.

[2] Director, Division of Sport Fish, Alaska Department of Fish and Game, Juneau, AK 99801

to regulate and conserve fisheries. If today's fishery manager has any time to spare, then he may consider such exotic topics as the quality of fishing opportunities and resource use ethics. Fishery managers today in the western states, and this is particularly true in Alaska, are spending less time in hip boots and more time defending assaults on the aquatic environment. Fishery managers are required to think in terms of political tradeoffs, mitigation exchanges and litigation, and have little or no time to seriously think about angler use ethics or angler education.

It is my belief that the American angler in the future will seek an angling experience with a level of quality higher than present fishery programs are providing especially in the quality of angler habitat. If the experience of angling is to improve, then present opportunities must either be maintained or improved. Standards of "quality experiences" have to be established now and cannot wait until later when it may be politically and/or economically unfeasible.

Land managers cannot continue to subscribe to the old myth of multiple-use as originally promulgated. We have learned in Alaska that multiple-use too often means degradation of angling quality. In our definition of quality fishing management we include and rank angler habitat next to fish.

Perhaps a better definition of quality fishery management as practiced in Alaska would be wilderness fishery management. With this definition we can consider the fish and angler habitat needs without distinction. You might say that good angler habitat management is also good fishery habitat management. We can cite several examples of the need to consider angler habitat in Southeast Alaska. About six years ago the U.S. Forest Service allowed a timber sale that resulted in clear cutting an entire watershed leaving only a fringe of trees around the lake centered in the cutting area. While the native cutthroat fishery has not declined in this lake, angler visitations dropped dramatically. Anglers simply did not like staring at a clear-cut hillside. Their sense of aesthetics was offended. Logging activities in Southeast Alaska have further impacted anglers through clear cutting by making streams inaccessible by leaving all slash in place. Little or no thought is given to how anglers would gain access to the streams.

Clearly if we are to provide wilderness fisheries in the future then we must classify those watersheds with high quality sport fishing values as single-use for that purpose. An inventory of high quality sport fishing watersheds in Southeast Alaska was completed over a decade ago. Forty drainages were selected and classified as high value recreational fishing areas. To date no progress has been made to place these waters under protective land use classification other than Admiralty Island, which was classified in its entirety as a National Monument under Forest Service management thus affording protection to all streams within the boundaries of Admiralty Island from the impact of development activities.

QUALITY FISHING

To some anglers, quality fishing means large-sized trophy fish. To serve these anglers, since 1966 the Department of Fish and Game has managed selected streams and drainages in the Bristol Bay area for trophy-sized rainbow trout. This program places a high premium on a chance to fish for a State- or even world-record-sized resident rainbow trout. It provides uniquely beautiful and particularly hard fighting stocks of fish in a natural setting of outstanding beauty.

When considering regulations governing quality fisheries use, it is extremely important that the protection of the breeding populations and the time, methods and harvest must be fitted to the angler use and to the productivity of the water.

The Kvichak watershed of Bristol Bay which encompasses Lake Iliamna and its tributaries is presently the only designated wild trout management area in Alaska. Assignment of this designation means that regulations are applied to maintain the special combination of qualities including wilderness surroundings and abundant numbers of large-sized rainbow trout. Methods and means of angling are restricted to unbaited, single hook, artificial lures in all streams during the ice-free seasonal period. Means of access are restricted to fixed-wing aircraft with helicopters prohibited from transporting anglers and sport-caught fish. The bag and possession limit for rainbow trout is restricted to five in possession and only one rainbow trout 20 inches and over in length in the daily bag limit. Hook and release fishing is encouraged as very large numbers of fish are caught in an average day's angling.

The Bristol Bay wild trout management program is enthusiastically accepted by anglers because it is successful. It provides large wild rainbow trout up to twenty pounds and places high premium on a chance to fish a stream that is virtually pristine and to observe other wildlife such as eagles and grizzly bear while angling.

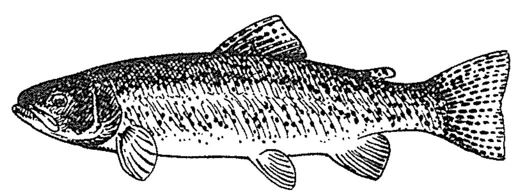
The important overall factor to be considered in managing quality fishing is aesthetics. Our all-encompassing definition of esthetics in quality fishing covers the full spectrum. It ranges from the anticipation involved in the planning of a fishing trip, and the smell of fresh-caught fish frying, to relating memories of a past angling adventure and reliving its highlights. Solitude and natural areas have been identified as important elements due to the increasingly recognized need of mankind to contact nature, and to undergo wilderness experiences.

Accordingly, the total experience must be considered in quality sport fish program planning. However, this is not to detract from the act of angling. The challenge of testing one's skill against a trophy-sized or unique species of fish, experiencing natural conditions (which in itself can be a challenge) is often a once-in-a-lifetime angler experience. Alaska has several unique fish species that either do not occur in other states or are very limited elsewhere, either in number or distribution. For example, in the Northern Hemisphere unique to Alaska and Canada, the sheefish is fabled for its high-leaping acrobatics and size. Weights can exceed 50 pounds. Sheefish are a worthy adversary for anglers of the highest skill. Add to the sheefish the Arctic char and Arctic grayling, and it can be seen why Alaska has a reputation for a unique variety of fresh-water fishing. Alaska is a rich source of such angling opportunities.

We plan to expand the traditional management objectives, in which management of fish numbers is a prime objective, to management of people to meet their aesthetic, and psycholgical needs. Some management techniques that might be used to accomplish these objectives are restricting access to quality fishing areas by limiting the number of access points and the extent of development. Campgrounds or picnic grounds adjacent to quality fishing streams or lakes would be discouraged. Commercial uses of all kinds could either be prohibited, discouraged, or severely limited. Litter problems will be managed to some extent by regulations prohibiting the use of nonburnable food containers and intensive educational programs promoting resource use ethics.

If we are to continue to have wilderness and wild fisheries in the future, then we must designate those watersheds now as single use for that purpose. Development activities must be restricted and the number of people using a particular watershed in a specified time frame would be regulated. Acceptance of these concepts will be difficult and/or impossible to achieve for fishery managers without public education and public support. The mechanics for a system of limiting public use are numerous but would embody a reservation system and subjective decisions as to how many people should fish an area on a daily basis and still preserve the qualities established for a wild-fishing experience.

The implementation of a quality fishing management program involves some departures from the goals of standard management practices. Regulations related to quality fishing would emphasize the aesthetically oriented use of solitude and natural values as much as possible. Imposing more restrictive bag limits and fishing methods will prevent overharvest and spread the available large fish among a greater number of anglers, thus affording the optimum possible opportunity per angler for taking large or trophy-sized fish. It is evident that a management concept that seeks solely to produce a maximum yield of protein will not accommodate current or future needs of anglers who are seeking values other than pounds of fish harvested.



MONTANA'S MADISON RIVER - A CONTINUUM OF MANAGEMENT CHALLENGE[1]

Ronald G. Marcoux[2]

Abstract. A combined trout population-fisherman harvest study was begun on the upper Madison in 1975. Initial results found unusually high summer trout mortality rates (70%) with correspondingly low winter rates (5-15%). Fisherman harvest did not explain the high summer rates. A two-year fishing closure showed summer mortality rates reducing to less than 30% and trout populations increased dramatically. Implementation of a catch and release-artificial lure regulation also decreased summer mortality rates and allowed for a population increase the first year. The number of hours fished declined by 40% during the first year of catch and release but was slightly higher than pre-restrictive levels the second year. Long-term data are needed to fully evaluate restrictive regulations.

BACKGROUND

Reflecting back to Wild Trout Symposium I in 1974, I remember a talk by Bob Hunt of Wisconsin where he believed that trout fishing regulations should assume first priority where (1) habitat quality is not an issue or (2) the threat of overfishing is so serious that it must receive special management attention (King 1975).

For many years habitat issues dominated our management approach to "keep a quality Madison River fishery." First, Montana Power who controls flows at Hebgen Dam, a major storage reservoir for downstream power production and Ennis Dam where low-head hydropower is produced, modified flow regimes to benefit the fishery. Spring flows were increased and water stored during high flow periods rather than the low flow winter period. Trout populations responded significantly to these management changes (Vincent 1969).

In the 1969 Montana legislature, water was appropriated instream to provide for preservation of the fisheries in the Madison River, thus publicly recognizing the habitat needs of this renowned "blue ribbon" fishery. Subsequent studies on the effects of planting hatchery trout on wild trout populations also led to increases in the wild trout fishery (Vincent 1973), and in 1973 led to a wild trout management policy on the entire Madison River in Montana which today remains a popular program with considerable support. Montana's Water Quality Act provides for protection of water quality and Montana Stream Preservation Acts give relative assurance for protection of the natural channel characteristics and in many cases the associated riparian habitat.

Other than the threat of subdivisions ruining the aesthetic values of the Madison, and a thermal problem below Ennis Dam, which is being studied, the Madison is a Montana river where habitat quality and fishermen impacts share equal management priority.

The Madison River is divided into two areas. The upper Madison from Quake Lake to Ennis Lake is mostly single channeled, rarely over four feet deep, with a riffle-run pattern that leaves the trout rather vulnerable to the angler. Flows range from 1000 to 1500 cfs entering Ennis Lake. With the exception of a section with many brushy channels where brown trout are abundant, rainbow is the dominant species.

The upper river with its high productivity, good water temperatures, generally good flow regimes, high scenic values and renowned salmon fly hatch has been a primary attraction to

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[1] Paper presented at the Wild Trout Symposium II, Yellowstone National Park, Mammoth, Wyoming, September 24-25, 1979.

[2] Regional Fisheries Manager, Montana Department of Fish, Wildlife and Parks, Bozeman, Montana.

anglers from around the world. Fishing pressure is greater here than on most other Montana rivers and continues to increase. Fisherman use averaged 252 fisherman days/mile in 1952, 650 in 1967, and 953 in 1975.

The lower Madison from Ennis Lake to its mouth still has environmental influences that impair the fishing quality. The thermal influence of shallow Ennis Lake which averages nine feet in depth, frequently raises summer water temperatures to 80° F (Vincent 1978a) and summer trout fishing is virtually nil. Management emphasis is directed toward solving this thermal problem via a Blue Ribbons APO Thermal Steering Committee (Shouse 1978).

FISHERMAN HARVEST - TROUT POPULATION STUDIES

Following the implementation of the wild trout management policy in 1973 on the upper Madison, a section in the brushy channels area about 15 miles upstream from Ennis Lake continued to show annual increases in both number and size of the wild trout populations (Vincent 1976). Upstream in the West Fork of the Madison area, where a predominately rainbow fishery was found, fishermen complained that, although fishing was good, the size of trout was declining.

In 1975 and 1976, the Department began monitoring fisherman harvest and trout populations in a 4.5 mile section (Snoball), approximately 12 miles downstream from Quake Lake. A ten fish or ten pounds and one fish regulation was in effect with a season length from the third Saturday in May through February. Estimates of angling pressure revealed that during the May 15 - September 15 period in 1975 when no float fishing was allowed, the total angling pressure was 3238 hours versus 7867 hours in 1976 when float and shore fishing were both allowed (Vincent 1977). An average of 19 float fishing boats per day were observed in 1976 with 75% of them commercially guided. Non-residents made up over 85% of the fishermen.

Fly fishermen increased from 39% of total anglers in 1975 to 60% in 1976, thus reflecting the boat use which is primarily fly fishermen. The number of released fish "seven inches and greater" increased during the float fishing year primarily due to the increase in fly fishermen who tend to release more fish. The total harvest of trout seven inches or greater decreased from 21% to 17% of the spring populations as a result of more being released even though angling pressure doubled from the previous year.

Of greatest biological significance, however, was unusually high summer mortality rates observed for III+ rainbow and brown trout in the section. Summer mortality rates were about 70% (Vincent 1977) with winter rates ranging from 5-15%. Mortality in this instance means the loss of fish either through natural causes, harvest, or catch and release mortality. Both rates were unusual with respect to other Montana rivers where mortality rates are more evenly distributed between summer and winter with winter frequently experiencing higher rates. Since the high summer mortality rates of large trout could not be totally explained by harvest rates (less than 35%), other factors were considered that could possibly influence mortality rates. These included: (1) Natural population dynamics for this area; (2) A possible environmental factor and/or; (3) A combination of harvest, natural, and release mortality.

To define fisherman impacts, a fishing closure was imposed in 1977 on the six mile Snoball section and another intensively fished control section (Pine Butte) was established where fisherman use was monitored for fisherman harvest-trout population relationships.

First Year Closure Results

Summer mortality rates for the wild trout in the "closed to fishing" section (Snoball) dropped dramatically from over 70% to less than 20% during the first summer of closure. Winter mortality rates still remained low and thus the populations of both rainbow and brown trout increased over 100%.

Mortality rates in the Pine Butte section where a ten trout or ten pounds and one trout limit was allowed, remained high, with rainbow trout populations experiencing the highest losses. Fisherman harvest alone accounted for 63% of the spring numbers of IV and older rainbow trout (Vincent 1978b).

With this data as background, the fisherman was shown to have a significant influence on the wild trout populations and in particular the larger trout. The Department then established a management goal for the Madison which is to provide the opportunity to catch wild trout in the 14-18 inch range. Since this goal could not be attained with the regulations of ten fish or ten pounds and one fish, and the fact that fishermen generally were selective to larger fish, additional restrictions were imposed. A catch and release artificial lure regulation was implemented in 1977 with the objective of reducing fishing mortality as much as possible and in an attempt to increase the population of larger trout. The closure (Snoball) was maintained to provide data as to the true fishery potential of the Madison under current habitat limitations.

Second Year Closure and Catch and Release Results

After two years of closure, the Snoball section showed an increase of trout over 12 inches ranging from 225% for rainbow to 341% for brown trout (Table 1). Summer mortality rates increased from the 1977 rate of 18% to 30% indicating the population was beginning to approach the true carrying capacity governed by limiting factors such as flow, water quality, habitat and food. The number of rainbow trout 15 inches and greater had more than doubled the first year after closure, but did not show a continuing increase in the second year.

About 25 brown trout per mile over 15 inches were found in the Snoball section for the two years prior to closure and their numbers increased to 84 the first year after closure and to 137 the second year.

After one year of catch and release-artificial lure regulations on the Pine Butte section in 1978, the number of trout 12 inches and larger increased from 555 per mile to 1169 per mile (Table 2). Rainbow trout over 15 inches did not show an increase, while brown trout increased from 106 to 159. Growth rates of brown trout were greater than for rainbow and this partially accounts for the movement of the species into the upper size category. The previously low numbers of rainbow over 12 inches, the slower growth rate, habitat limitations, or release mortality may be factors limiting the increase in rainbow over 15 inches in the catch and release section. The number of trout caught per hour increased from 1.32 in 1977 to 2.75 during the year of catch and release fishing.

Fishing pressure during the first year of catch and release fishing dropped approximately 40% which was similar to the amount of use bait fishermen had exerted prior to the restrictive regulations. In 1979, pressure increased and is slightly higher than pre-restrictive regulation levels.

Table 1. Changes in number of brown and rainbow trout per mile in the Snoball section (4.5 miles) following two years of fishing closure.[1/]

	Limit - 10 trout or 10 lbs. and 1 trout 1975	1976	Closed to Fishing 1977	1978
Rainbow Trout				
12" and larger	275	176	509	572
15" and larger	25	28	64	55
Brown Trout				
12" and larger	79	96	273	424
15" and larger	26	21	84	137

[1/] Data from Vincent 1979.

Table 2. Changes in number of brown and rainbow trout per mile in the Pine Butte section (3.0 miles) following one year of catch and release fishing.[1/]

	Limit - 10 trout or 10 lbs. and 1 trout 1977	Catch and Release Artificial Lure 1978
Rainbow Trout		
12" and larger	277	720
15" and larger	62	62
Brown Trout		
12" and larger	278	449
15" and larger	106	159

[1/] Data from Vincent 1979.

THE FUTURE

In a recent article in Trout Magazine (19(4)), Del Graff, Chief of Fisheries from Pennsylvania, indicates time is needed for evaluation of our restrictive regulation programs. After nearly five years of investigation on the Madison, it is clear that we do not yet have the answers to reach our goal. Mr. Graff's comments should be seriously pondered by the layman and professional. We can't react to a single year of data and be expected to predict what our results will be.

We need time, maybe ten years or more, to truly evaluate the closed section. What is the potential of the Madison to produce trout? Is the goal of having the opportunity to catch wild trout in the 14-18 inch size range realistic? The information from the closure would prove invaluable in evaluating our future management programs.

What are the impacts of releasing fish? We know about types of hooks, but catching and releasing a fish involves much more than the hook. Can releasing mortality have significant implications as angling pressure increases? These questions deserve answers and time is needed to answer them.

Today there is a general outcry from a segment of the fisherman population to intensively regulate our streams. Let's take a lesson from Pennsylvania where a moratorium was requested to evaluate special regulations before creating new ones (Graff 1977). Rather than implement a regulation for regulations sake, the layman and professional alike should work together to define the kind of fishery expected and establish a realistic goal of management based on the capability of the stream to produce. If regulations are then geared to attain the goal, we'll all be better satisfied with the fisheries of the future. But first, let's be wary and ensure we keep equal energies for the assaults on the habitat which will, in the end, mean survival or loss of fishing as we know it today.

REFERENCES CITED

Graff, D.R. 1977. Pennsylvania Angler. June, 1977:11-15.

King, W. (ed.) 1975. Proceedings of the Wild Trout Management Symposium at Yellowstone National Park. Trout Unlimited, Inc., and U.S. Department of the Interior:103 p.

Shouse, J. A. 1978. Trout. 19(1):33-36.

Vincent, E.R. 1969. Evaluation of river fish populations. Job completion report. Montana Project No. F-9-R-17, Job VII.

Vincent, E.R. 1973. Evaluation of river fish populations. Job completion report. Montana Project No. F-9-R-20, Job III-a.

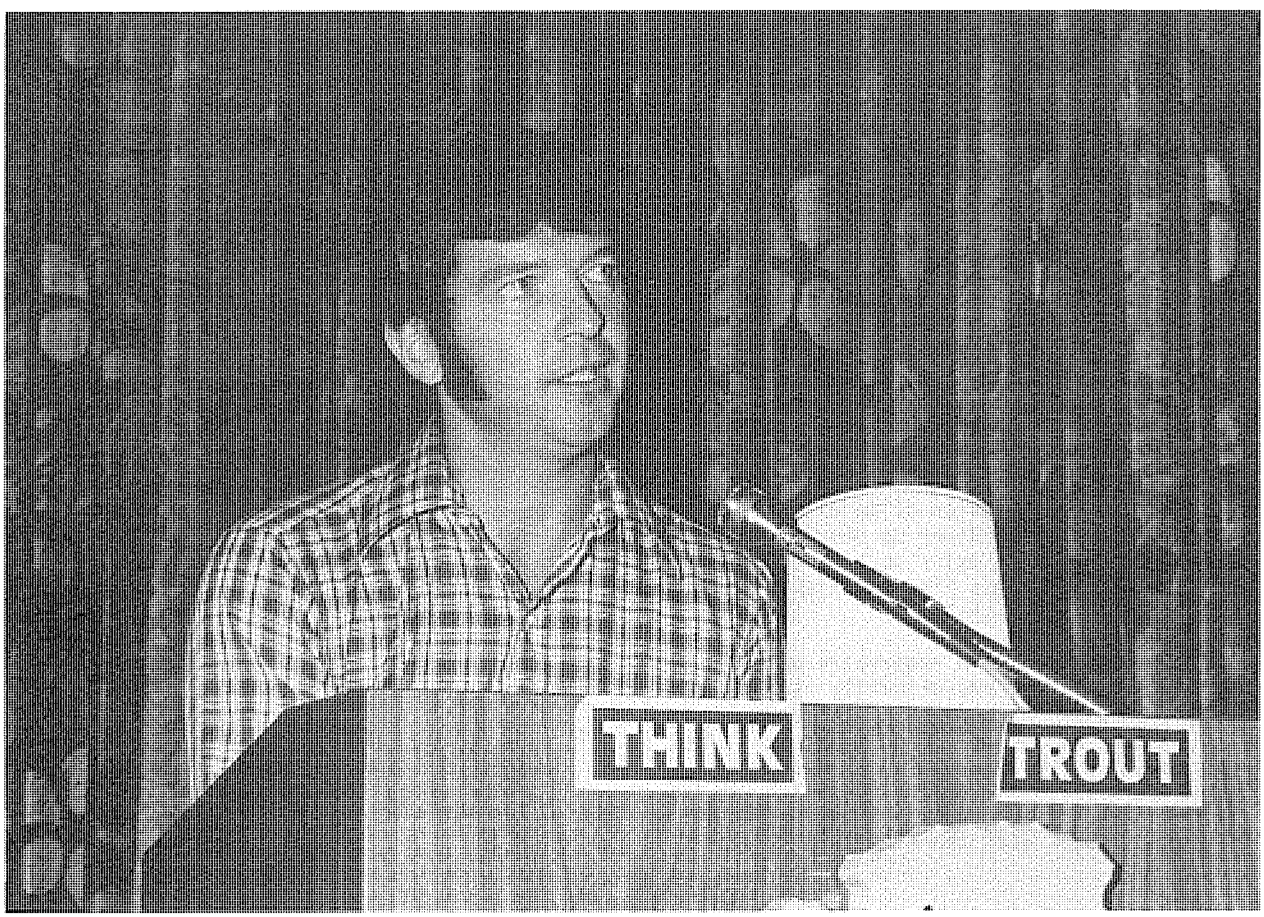
Vincent, E.R. 1976. Inventory and survey of the waters of the project area. Job progress report. Montana Project No. F-9-R-24, Job I-a.

Vincent, E.R. 1977. Madison River trout harvest study. Job progress report. Montana Project No. F-9-R-25, Job II-b.

Vincent, E.R. 1978a. Madison River temperature study. Job progress report. Montana Project No. F-9-R-26, Job II-a.

Vincent, E.R. 1978b. Madison River trout harvest study. Job progress report. Montana Project No. F-9-R-26, Job II-b.

Vincent, E.R. 1979. Madison River - West Gallatin River trout harvest study. Job progress report. Montana Project No. F-9-R-27, Job II-b.



REHABILITATION OF SALMONID FISH STREAMS THROUGH UPSTREAM STORAGE[1]

Douglas Dompier[2]
John R. Woodworth[3]

The Bumping Lake Project in the state of Washington, a joint proposal of the Water and Power Resources Service and the U.S. Fish and Wildlife Service, would enlarge an existing reservoir on the Yakima River System from 33,700 acre feet to 458,000 acre feet of which 342,000 acre feet would be for augmented fish flows. By exchanging water with five other reservoirs on the system 340 miles of spawning, rearing, and resting areas for salmon and steelhead would be restored. Obstacles such as dams and diversions would be laddered and screened and hatchery facilities would be built to restore the system with salmon and steelhead. It is estimated that runs could be increased from a present low of 5,000 fish to approximately 87,000 fish with this project. The costs of enlarging Bumping Lake and constructing the associated facilities based on October 1978 prices, totals about $125,000. Annual benefits would outweigh annual costs by a ratio of 1.3 to 1. The U.S. Congress has authorized and funded four studies in Oregon at the request of the Oregon Fish and Wildlife Department to see if projects similar to Bumping Lake can be developed there.

Upstream storage for fish flow augmentation has a tremendous potential for restoring streams for fish production. An example of this type of restoration can be found in the joint proposal of the U.S. Water and Power Resources Service and the U.S. Fish and Wildlife Service for the Bumping Lake Enlargement in the State of Washington. The dominant feature of this proposal is the expansion of an existing reservoir in the Yakima River to provide additional new storage water, a major portion of which would be used for fish flow enhancement in the entire Yakima River system.

There are presently six reservoirs on the Yakima system which are primarily used for irrigation purposes, including the existing 33,700 acre foot Bumping Lake Reservoir. The enlargement which is proposed at the site would store 458,000 acre feet of which 324,000 acre feet would be for augmented fish flows. By trading water with the other five storage reservoirs, some 340 miles of spawning, rearing, and resting areas for steelhead and salmon in the Yakima River System can be improved. Bumping Lake would be a major step in restoring this once productive habitat.

The project would also involve laddering many of the obstacles on the Yakima River as well as improved screening of the diversions where downstream migrants could be lost. Additionally, hatchery facilities would be built to produce approximately nine million salmon and steelhead annually to be released in the upper tributaries of the Yakima system to eventually produce a self-perpetuating population of salmon and steelhead.

[1]Paper presented at the Wild Trout Symposium II September 24-25, 1979, Yellowstone National Park, Wyoming

[2]Manager, Technical Fisheries Services, Columbia River Intertribal Fish Commission, Portland, OR

[3]Regional Environmental Officer, U.S. Water and Power Resources Service, Boise, Idaho

Prior to 1880 it is estimated that over 600,000 salmon and steelhead migrated annually into the Yakima River System. The local Indians on the Yakima system harvested approximately 160,000 fish, the greatest portion of which were dried for personal consumption and traded during the winter. The fish in the Yakima River system also contributed to the commercial fishery in the lower Columbia River which reached a high of 530,000 cases in 1880. It is estimated that by 1905 salmon and steelhead populations in the Yakima river system had declined to about 10 percent of their former abundance due to irrigation diversions, low flows, and high temperatures in the lower main stem.

By 1920, impassable storage dams, irrigation diversions, and uncontrolled fishing in the Yakima system, combined with intensive commercial fishing in the Columbia River, reduced the numbers of salmon and steelhead returning to the Yakima River to approximately 11,000 fish.

A rehabilitation program was initiated around 1920 in the Yakima Basin, and numerous fish ladders and screens were installed under a cooperative effort with the Washington Departments of Fishery and Game and the U.S. Fish and Wildlife Service. By 1960, salmon-steelhead populations had increased to about 19,000 fish, largely as a result of these measures.

Since 1958, the Washington Department of Game has been augmenting summer run steelhead populations in the Yakima by stocking, and the Washington Department of Fisheries has augmented anadromous fish runs by occasionally stocking juvenile spring chinook and coho salmon in the system. In spite of this, the runs have again declined to an all time low. In 1977, fewer than 200 chinook salmon spawned in the Yakima.

Cooperative studies by the National Marine Fisheries Service, Fish and Wildlife Service, Washington Department of Game, Washington Department of Fisheries, and the Water and Power Resources Service, have determined that improving stream flows and fish passage at existing diversions dams could provide a total natural spawning escapement of 11,400 spring chinook, 2,800 fall chinook, 21,350 coho salmon, and 13,600 steelhead trout in the Yakima River system. Following the establishment of the natural runs, hatching facilities would be used to produce additional fish. These fish would be planted in streams determined by the Washington Department of Fisheries, the Washington Department of Game, Fish and Wildlife Service, and the National Marine Fisheries Service to supplement existing runs and re-establish past runs. The total enhancement with the project would increase spawning escapement of approximately 76,000 salmon and steelhead. Establishment of the natural runs would take a minimum of three years for coho salmon and five years for chinook salmon and steelhead trout.

The costs of enlarging Bumping Lake and constructing the associated facilities based on October 1978 prices, totals about $125,000,000. However, annual benefits outweigh annual costs by a ratio of about 1.3 to 1. In other words, studies indicate that for every $1.00 invested, the project will yield benefits of $1.30.

On June 20, 1979, the Secretary of the Interior sent the feasibility report on the plan of development for Bumping Lake Enlargements to the President through the Office of Management and Budget recommending the project be authorized for construction.

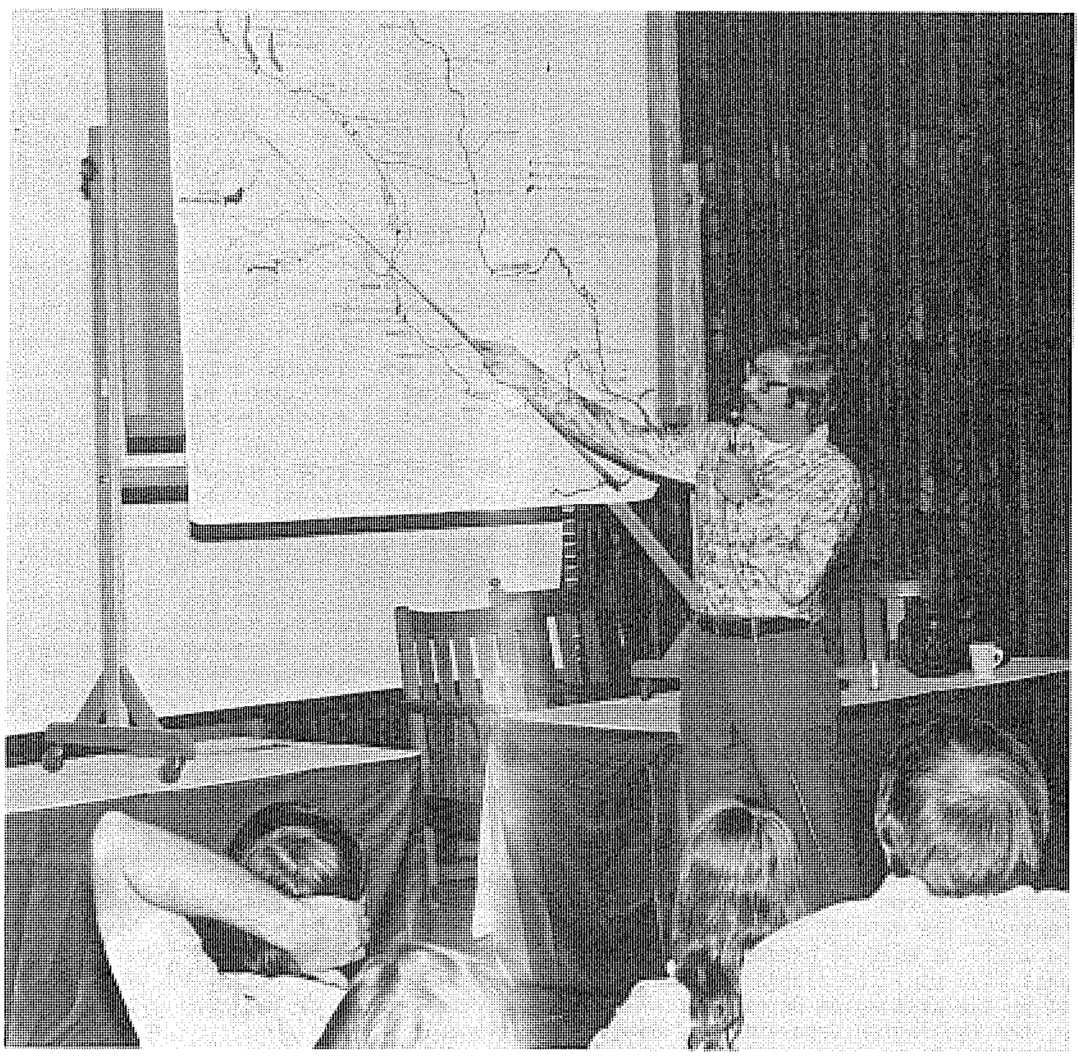
Fish and game departments and other organizations interested in restoration of anadromous fish habitats in the northwest are requesting that headwaters storage potentials in other important river basins be identified and evaluated.

Up to this point, we've been talking about anadromous fish projects associated with the Columbia River. The reason for this is two-fold. First, the Columbia River was once and may still be the greatest salmon and steelhead river system in the world and it is in extremely critical condition for just about all runs of salmon and steelhead. Secondly, the benefits associated with these fish are so widespread regionally that it has been determined that the cost of doing these kinds of projects for the anadromous fish would be non-reimburseable. That is, the Federal government would pick up the tab for anadromous fish measures. The fish from the Columbia System are harvested in the ocean all the way from central California to Alaska, and, of course, by three states in the Columbia River system (Washington, Oregon, Idaho), and treaty Indian fishermen.

We believe, however, that the ideas expressed here concerning headwater storage and elimination of obstacles and diversion losses would apply to resident as well as anadromous fish. In particular, we think that many trout streams throughout the country which have fallen victim to problems of low stream flows, high temperatures, impassable obstacles, and unscreened diversions can be restored with similar general plans.

We think there is a fantastic potential for the restoration of streams throughout the Northwest, the Nation, and perhaps worldwide, using the upstream storage for fish flows as the principal factor.

However, there is a major problem. That problem lies with the "Fish and Wildlife Fraternity." Fish and wildlifers in general are so used to being in a defensive stance regarding reservoir development that many of them find it impossible to get on the offense and go after a restoration or enhancement program. They have been so ingrained with fighting the dam builders that it is impossible for them to consider a dam as a solution to a fisheries or wildlife problem. We feel that once one of these projects is built and it is demonstrated what can be done to restore streams, people all over the world will endorse the concept. Already this year the Water and Power Resources Service has launched four new studies on streams in Oregon at the request of the Oregon Fish and Wildlife Department to see if there is a potential for restoring these streams for salmon and steelhead.



THE ATLANTIC SALMON IN NEW ENGLAND[1]

Lawrence W. Stolte[2]

Abstract

A great many successes have been recorded in the New England Atlantic salmon restoration effort during the past decade. There remain however, a great many challenges: development of brood stock, the high-seas fisheries, fish passage problems, and hydro development are a few. One of the most important management concerns will address utilization of the resource. Serious conflicts may be just around the corner.

INTRODUCTION

During the last few years, the Atlantic salmon (*Salmo salar* Linnaeus), as it relates to New England, has been popularized region-wide and in some cases nation-wide. Authors such as; Clark (1979), Gephard (1979), Kimball and Stolte (1978), Oatis (1977), Pero (1977), Williams (1977), Alexander (1976), Keim (1976), and Linnane (1976), have done a great deal to provide the public with knowledge on this noble species. I suspect that in the future there will be an acceleration in the amount of copy produced.

For the first time in a rather long, difficult struggle, the Atlantic salmon program has generated results on all fronts worth cheering about. The rod catch in the Penobscot River in 1978 was the highest ever recorded. More salmon returned to the Connecticut River in 1978 than had been observed in the last 80 years. Hatchery smolt production capabilities have increased dramatically in the last few years and smolt stocking in the Merrimack River commenced. Fish passage problems are being solved and new facilities constructed. Yes, there has been a great deal to cheer about. However, there remains a real need for those of us who will write or speak of this species to excercise caution.

Today's titles such as, "The Return of a Native", or "The Re-Creation of a Fishery", could easily be replaced with tomorrow's headlines; "Angry Trout Fishermen Confront Salmon Anglers on the White River", or "Management Conflicts Bring the New England Salmon Program to a Halt". Today, Atlantic salmon populations in New England are still precariously low, probably numbering less than 5,000 individuals. Of this total, an optimistic estimate for the number of wild fish might be 3,000. The existing and potential problems that confront this species are relatively easy to define but in many cases, of the utmost difficulty to solve.

THE NEW ENGLAND SCENE

Today's Atlantic salmon program is one of restoring and enhancing. If one interprets restoration to mean, as defined in Webster, "a bringing back to a former position or condition", there will be little hope of truly restoring the species. The probability is also extemely high that any salmon run developed will require significant and continual hatchery augmentation. Thus, the U.S. Fish and Wildlife Service has loosely defined restoration as the development and maintenance of Atlantic salmon populations in suitable areas of their historical habitat.

Since only six relatively small rivers in New England, all situated within Maine, now sustain reproducing salmon populations, the Atlantic salmon hatchery will play a key role in our restoration efforts (fig. 1). This area, formerly a one State/one hatchery program has now grown to a six State/nine hatchery program including one proposed and three existing smolt-release facilities and two proposed and three existing broodstock holding areas.

The program must be considered relatively small when compared to salmon programs in the Pacific Northwest. However, in spite of its size, it is rather complex, which would be expected when 10 State and two Federal agencies are involved (fig. 2). The great number of meetings, coordination, and cooperation required often overwhelm those just coming into

[1]Paper presented at the Wild Trout II Symposium, Yellowstone National Park, Sept. 24-25, 1979.

[2]Atlantic Salmon Planner, USFWS, Laconia, New Hampshire.

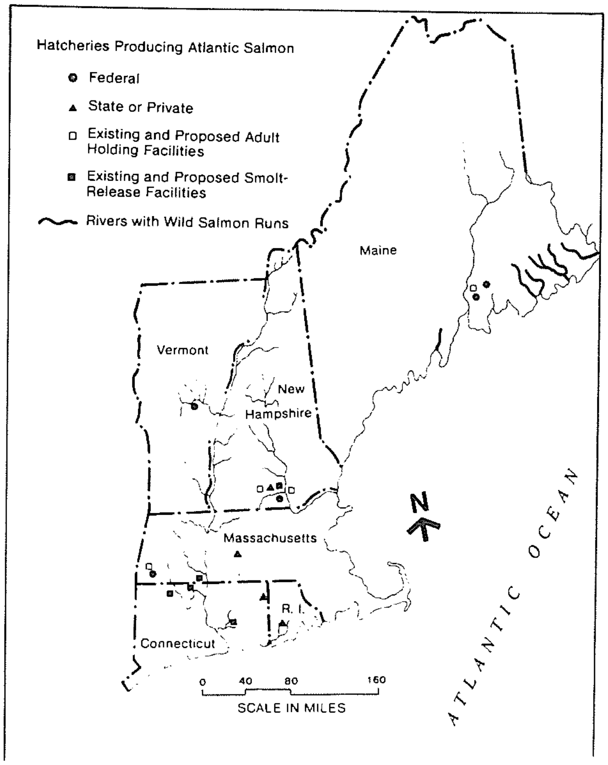


Figure 1.--The current Atlantic salmon fish cultural and release program addresses the six New England States and comprises nine hatcheries and a number of existing and proposed adult holding and smolt release facilities.

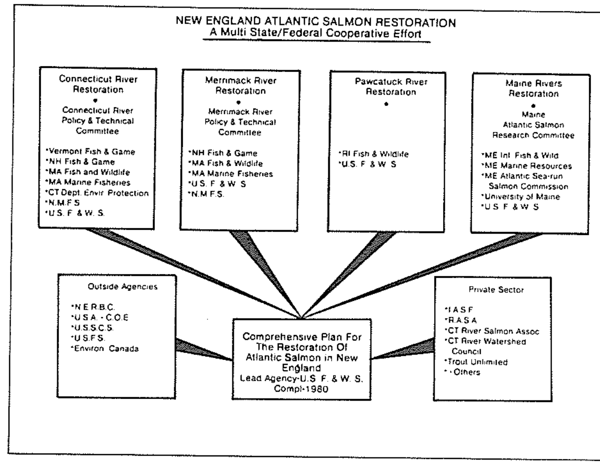


Figure 2.--The New England Atlantic salmon restoration program is a multi-State/Federal effort.

the program. This operating framework, although cumbersome at times, has proven to be an effective means of getting the job done.

A very important part of our current program addresses planning. Three rivers, the Connecticut, the Merrimack, and the Pawcatuck are being addressed in a comprehensive restoration plan (fig. 3). It is likely that an additional nine rivers located in Maine will also be included. The major operational activities will probably involve four systems; the three rivers previously mentioned and in addition, the Penobscot River.

Atlantic salmon habitat has been identified and quantified in these rivers. Estimated spawning escapement needs, wild smolt production estimates in relation to the habitat surveys, adult salmon returns, and potential problem areas have been projected.

Although the comprehensive plan is not yet completed, I would hasten to speculate that the long-term objective will be to develop and maintain runs of Atlantic salmon of approximately 15,500 individuals in the four river systems (6,000 in the Connecticut River, 400 in the Pawcatuck River, 2,700 in the Merrimack River, and 6,400 in the Penobscot River). Ideally, one-third of the fish could be angled without impacting the spawning populations.

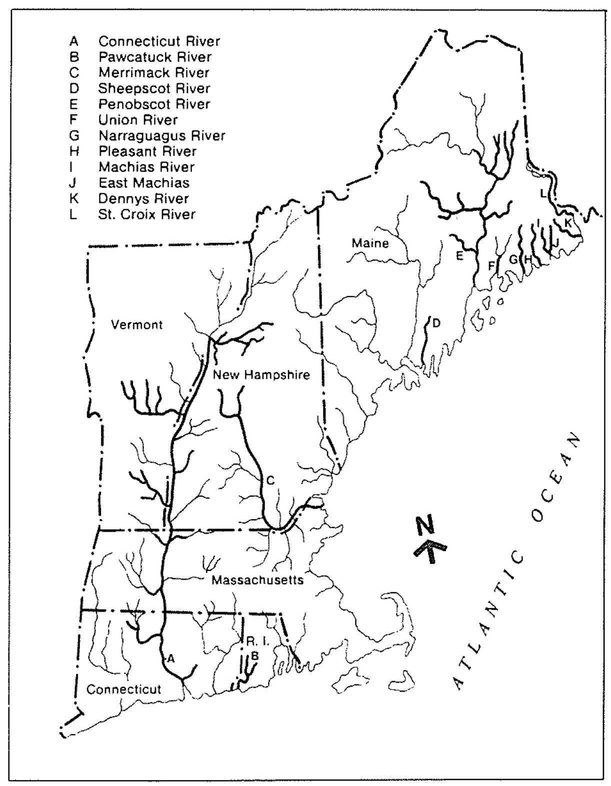


Figure 3.--The proposed Atlantic salmon restoration and enhancement program may address twelve rivers in the future.

Admittedly, the numbers are small, and will require a considerable hatchery program. They would however, represent almost an eight-fold increase in the number of salmon currently entering the four rivers.

MANAGEMENT OF THE ATLANTIC SALMON

If the restoration effort is to succeed, some very important management decisions will have to be made. Tremendous management complexities are expected; complexities that are inevitable when a species travels within an area of international jurisdiction, multi-State jurisdiction, and within a State, multiple-agency jurisdiction -- all the while the object of competitive user groups. Management however, must address much more than the utilization of the resource.

In order to restore Atlantic salmon one must first have salmon to work with. The southern New England programs will require roughly 3,000,000 eggs annually. The current supply from these rivers is for all practical purposes zero. Out of necessity, Atlantic salmon eggs must be obtained from available sources in Canada and Maine. The choosing of a stock or stocks from which eggs are available is probably extremely critical to the restoration efforts.

There is evidence that Atlantic salmon hatchery smolts, when released into rivers other than their native stream experience lower rates of return (Ritter, 1975). The lower return rate appears to be more pronounced with the greater distance the stocks are transplanted from their native stream.

The manager may have to choose between filling his hatcheries with whatever salmon eggs are available or reducing his production at times and obtaining eggs from stocks closer to the river in question.

On the international scene, salmon originating from New England rivers are harvested commercially in Greenland and Canadian waters (fig. 4). During the period, 1966-1973, an average of 53% of the tag returns for hatchery smolts released into the Penobscot River came from these areas; 37% from Greenland waters and 16% from Canadian waters (Baum, 1974). For every tag returned from home waters, between one and two additional tags come from these distant fisheries.

Results from the tagging program for hatchery smolts released into the Connecticut River provide much the same data as those for salmon originating in Maine.

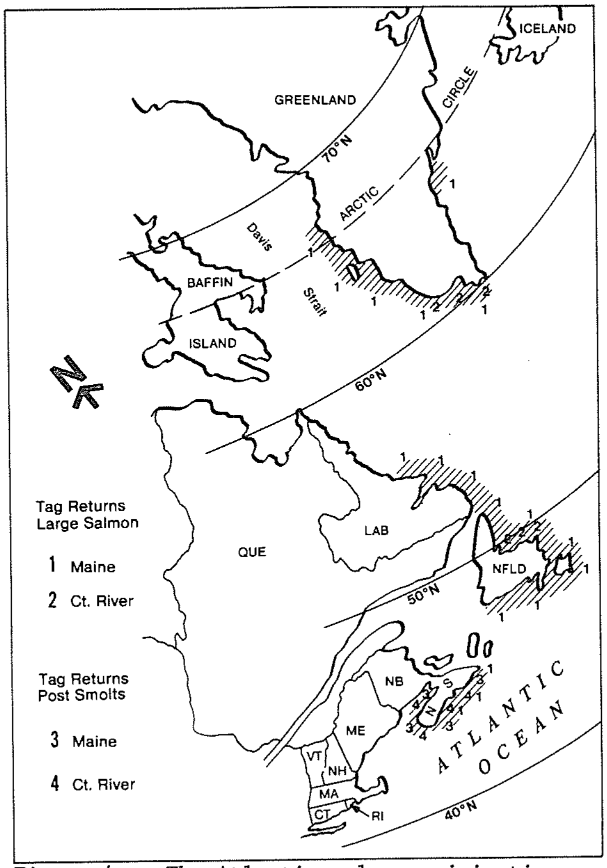


Figure 4.-- The Atlantic salmon originating from the Connecticut and Penobscot Rivers are harvested in a number of locations as the tag-return data indicate.

Although the idea of home river exploitation, i.e. limiting commercial fishing to the river of origin, is now an international issue, its feasibility is questionable in view of the traditionalism of the fisheries. Those of us involved with the restoration program are presently accepting the salmon losses due to the high-seas fisheries and are developing our plans accordingly.

Excluding the Penobscot River, providing returning salmon access to the spawning grounds is a major management concern (fig. 5). In spite of significant accomplishments in the mainstem of the Connecticut River, returning salmon will be denied access to many of the tributaries. The Pawcatuck River tributary system is obstructed as is the mainstem of the Merrimack River. Undoubtedly, short-term alternatives to upstream fish passage will have to be considered in many of the rivers.

The utilization of the resource by sport fishermen may become a very strong issue. Already, Richard Buck of the group, Restoration

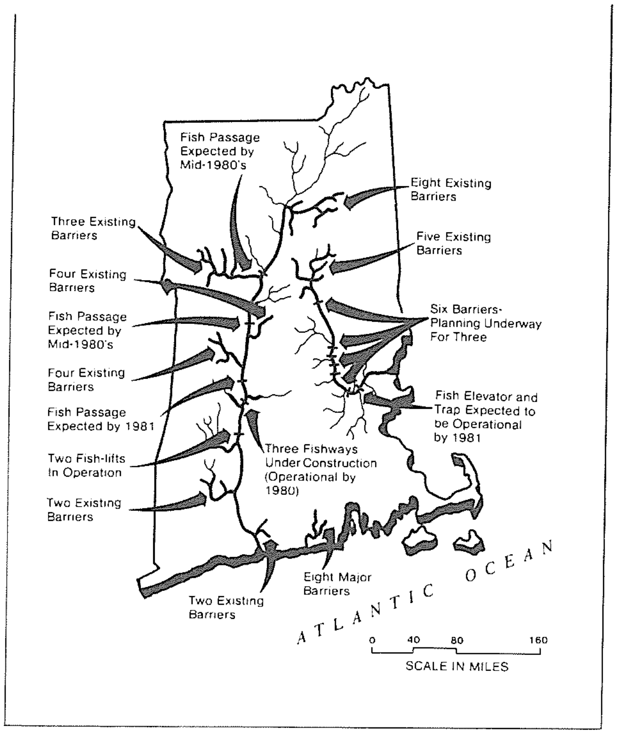


Figure 5.--There are many barriers that will will be important to the Atlantic salmon restoration efforts in the Merrimack, Connecticut, and Pawcatuck Rivers.

of Atlantic Salmon in America, Inc., has expressed a fear that New England's salmon rivers will be over-exploited by anglers before the fish has become securely restored (Clark, 1979). Limiting access to the rivers, through allocation, sale or lease of fishing rights, or some combination has been proposed (Clark, 1979) as have salmon sanctuaries regarding nursery and spawning areas (personal communication, Buck, 1979).

In spite of the goodness of many of the proposals aimed at protecting the developing salmon resource, they too often neglect existing fishery programs. The major rivers, such as the Penobscot, the Connecticut, and the Merrimack, have a diverse freshwater fish fauna. Anglers pursue chain pickerel (Esox niger Leseur), largemouth bass (Micropterus salmoides Lacepede), smallmouth bass (Micropterus dolomieui Lacepede), and many other warmwater game fish. In some areas wild populations of rainbow trout (Salmo gairdneiri Richardson), brown trout (Salmo trutta Linnaeus), and brook trout (Salvelinus fontinalis Mitchill) support significant sport fisheries (fig. 6). Additional areas support intensive sport fisheries for trout using put-and-take programs. What

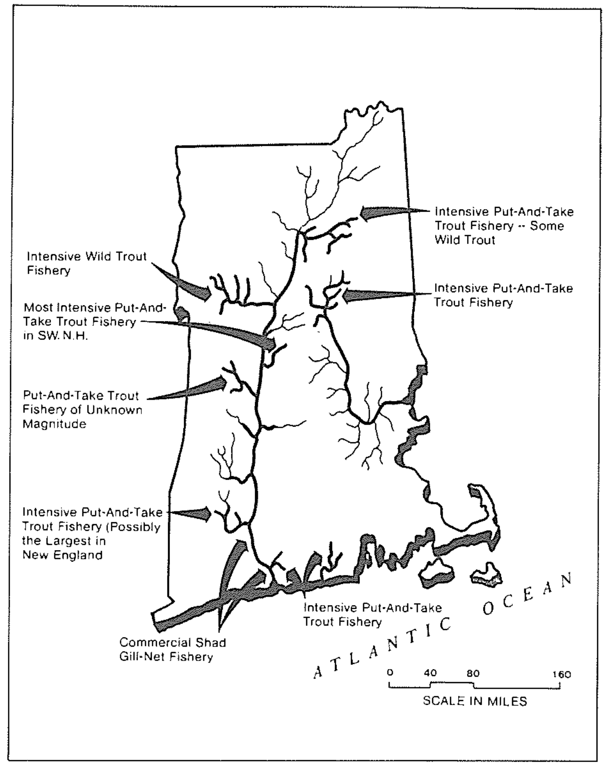


Figure 6.-- The Atlantic salmon restoration effort in southern New England faces many potential fisheries conflicts.

impact will many of the proposals have on these fisheries? There is every reason to believe that serious conflicts are waiting in the wings.

There are many more management issues that will have to be addressed in the future. The very real possibility that salmon produced in the headwater tributaries will be considerably different than their downriver counterparts in the larger rivers may necessitate the implementation of a variety of management programs. Water withdrawals and river flows in relation to hydro use and development is a concern. Downstream migrant losses at the hydro facilities is a concern. The potential from directed illegal harvest, poaching, of Atlantic salmon is a concern. Carter (1976) has discussed the serious nature of this activity in Canadian Atlantic salmon rivers. The gill-net fishery for American shad (Alosa sapidissima Wilson) in the lower Connecticut River, depending on its impact on the salmon restoration effort, may require the making of some very difficult decisions.

SUMMARY

In spite of the many problems that lie ahead, those of us involved with this species feel that her future is now brighter than it has been at any time in the last 40 years. Programs have become better organized and more realistic. The salmon run in the Penobscot River has increased from zero in the 1960's to greater than 2,000 in 1978. The availability of eggs from New England stocks is just around the corner. Fry stocking programs have shown that tributaries of the Connecticut and Merrimack Rivers are capable of supporting and producing Atlantic salmon smolts. For the first time in a long time the Atlantic salmon is being viewed as a single species in a multiple-species complex; a species that itself, will place specific demands on a water resource; demands that will be but a small segment of the existing and projected uses.

In the words of Tom Pero(1977), "Successfully restoring Atlantic salmon to the rivers of home will mean that for one of the few times in the history of civilization, a people will have revived a species its ancestors recklessly abused and exterminated. Restoring the salmon will not be easy. It will take enormous amounts of money, hard work and commitment. Mostly, it will take commitment. Only this will bring the salmon back. We will win, we will lose, we will compromise. But in the end, the salmon will win. And New England will be a better place."

LITERATURE CITED

Alexander, A.I. 1976. Restoration of the Atlantic salmon in Massachusetts. Trout. Fall Issue, Vol. 17, No. 4: pages 16-17, 39.

Baum, Edward. 1974. Tagged Atlantic salmon: where do they go? Maine Fish and Game Magazine. Summer Issue. Augusta, Maine.

Carter, Wilfred M. 1976. The poachers are robbing you. Trout. Fall Issue. Vol. 17, No. 4: pages 10-12, 36-38.

Clark, Tim. 1979. The return of a native. Yankee Magazine. Dublin, N.H. April: 100-107.

Gephard, Stephen. 1979. The Re-creation of a fishery. Fly Fisherman. April. Vol. 10, No. 4: pages 40-45.

Keim, Roger C. 1976. Maine salmon. Trout. Fall Issue. Vol. 17, No. 4: pages 28-30.

Kimball, Dan and Lawrence Stolte. 1978. Return of the Atlantic. Water Spectrum. Fall Issue. Vol. 10, No. 4: pages 33-40.

Linnane, George W. 1976. Maine salmon restoration program. Trout. Fall Issue. Vol. 17, No. 4: pages 31-32, 36.

Oatis, Peter H. 1977. The Merrimack River. Massachusetts Wildlife. May-June Issue. Vol. 27, No. 3: pages 2-7, 15.

Pero, Tom. 1977. Natural history series 26 - salmon. New England Outdoors. March. Vol. 3, No. 3: pages 32-37, 58.

Pero, Tom. 1977. Atlantic salmon --Part II. New England Outdoors. April. Vol. 3, No. 4: pages 38-40.

Ritter, John A. 1975. Lower ocean survival rates for hatchery-reared Atlantic salmon (Salmo salar) stocks released in rivers other than their native streams. ICES, C.M. 1975/ M:26. Anadromous and Catadromous Fish Committee. 10 pages.

Williams, Ted. 1977. A time without salmon. Trout and Salmon. Gray's Sporting Journal. Vol. 2, No. 2: pages 46-56.

WILD TROUT MANAGEMENT IN BRITISH COLUMBIA[1]

David W. Narver and Gerry D. Taylor[2]

Abstract.--"Wild trout" in British Columbia are synonymous with quality inland rainbow, sea-run cutthroat and steelhead fisheries. Although many inland lakes are relatively productive, coastal streams generally are not. In management, habitat protection is stressed and regulations provide diversity of angling experience. Habitat enhancement though modest, provides significant aid in meeting production goals. Most trout raised by fish culture facilities are direct progeny of wild stocks. There are likely few, if any, large wild trout producing systems left to be discovered.

INTRODUCTION

Much has been written and said about wild trout - value and management. In some areas of North America wild trout management is extremely controversial - simplistically, wild trout versus hatchery trout. In British Columbia, we have a wide variety of controversies regarding management of our freshwater fisheries, but a wild and hatchery trout schism is not high on the list. Most of our staff deal mainly with wild trout or stocks which by definition are only once removed from the wild.

As a contribution to this panel, we will discuss briefly our wild trout management programs in British Columbia which have depended mainly on habitat protection, regulation, and recently fish habitat improvement. There will be a disportionate treatment of steelhead management because of current accelerated funding through a federal/provincial program.

THE RESOURCE AND THE AGENCY

First let us introduce you to British Columbia. The Province is nearly 370,000 square miles (approximately one-third larger than Texas or three-fifths the size of Alaska) with a population of 2.6 million and growing at a rate of 1.4% per year. The licenced angler population of about 400,000 is increasing in absolute numbers at about 5% per year or 3.5 times the growth rate of the Provincial population. In addition, there are an estimated 50,000 juvenile anglers. Angling effort translates to over 5 million recreational days in freshwater and a catch of 9 million fish.

The Branch has an annual budget of $10 million, approximately one-half of which is allocated to various phases of fisheries management, including research, habitat protection and enforcement. Licence sales revenue from anglers is $2.3 million. The Branch is decentralized, divided into eight regions corresponding roughly to natural biophysical divisions of the province. Each of these regions has fisheries, wildlife, habitat protection, enforcement and information and education responsibility. Other provincial resource agencies such as forestry, agriculture, water resources, mining, etc. are also decentralized into these eight regions.

The fisheries staff in each region is composed of one to three fisheries professionals and technical support. Incredibly, some of our regions are larger than many states and some provinces. Our resource base consists of about 22,000 lakes and 37 major river systems plus tributaries and thousands of small coastal streams. As you can imagine, our first-time biological inventory of waters is not complete in the northern two-thirds of the province. In the central and southern parts of the province we have intensively managed waters providing high rates of recreation only since the 1950's.

[1]Paper presented at the Wild Trout II Symposium, Yellowstone National Park, Wyoming, September 24-25, 1979.

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Trout comprise only three of the thirteen gamefish species in the province, the remaining sixty species are mainly non-salmonids, widespread and not recreationally used. In the freshwaters of the coastal zone west of the Coast Mountains, and including Vancouver Island and the Queen Charlotte Islands, is primarily found anadromous cutthroat and rainbow (steelhead) trout and Dolly Varden char as well as resident cutthroat in nearly all lakes. Two or more of the five salmon species usually dominate the fish faunas in streams. The south-central part of the province from Prince George to the Washington border is rainbow country and contains many extremely rich lakes. There are now many times the rainbow lakes in this area than originally existed because of chemical rehabilitations, annual stocking of lakes with no spawning capability and the widespread creation of irrigation reservoirs. Lake "trout" are common in most lakes from Williams Lake north. Southeastern British Columbia (the Columbia River) drainage is resident rainbow, Yellowstone cutthroat and Dolly Varden country. This is an area of large lakes and rivers but relatively few small lakes. The area east of the Coast Mountains and north of Prince George contains numerous large lakes with lake "trout". Rainbow trout are common throughout the Pacific drainages and part of the Peace River. Dolly Varden occur throughout the area.

MANAGEMENT PHILOSOPHY AND STRATEGY

The purpose of freshwater fisheries management in British Columbia is to provide and maintain the widest possible range of angling experience--experiences ranging from wilderness angling, to restricted gear, to catch and release, to "put and take" fishing; from spiny-rays, catfish and carp to salmonids; from small streams to rivers; and from small, no motor lakes, to large lakes and reservoirs. In addition, twenty waters have been set aside for angling by juveniles, senior citizens and the handicapped. Such a purpose can be best supported in a region of wide biological, physical and demographic variation--British Columbia is highly variable in those respects.

The basic assumption in our management program directed towards providing a wide range of angling experience is to satisfy human needs for recreational fishing as a means of close personal involvement with fish in their natural habitat (fish for people). Additional assumptions are that the capture of desirable species in satisfactory numbers and sizes is important; that the angling environment is important; and that an equitable distribution of angling opportunity within the province is important.

In our salmonid program, which is by far our major effort, the main thrust is maintenance of natural production, and major segments of Fish and Wildlife Branch activities are in the areas of habitat protection and fisheries habitat improvement. However, in keeping with our overall goal we also have catch and release waters, fliesonly waters, "trophy" or "special" lakes and streams with strongly curtailed bag limits, as well as a strong hatchery program for small lakes lacking in spawning capability or subjected to heavy urban angling pressure. A firm biological and/or sociological rationale exists for each of these special regulations.

The major input in developing and modifying management programs comes from the angling public through club meetings, advisory groups and public meetings. This is not to say that we are doing an entirely adequate job of communicating with our clients; but we all know, often from personal "bloodshed", how vital it is to keep the public aware, involved and supportive. The Information and Education people can help, but it is often the field staff who can most effectively deal with individual client groups. Getting clubs or schools involved in management programs can be productive in our experience. Our own bias as lifelong anglers is that to be most effective, management, protection and research biologists should be active anglers--otherwise the credibility gap with user groups is a continuing problem.

All of our regional biologists have used angler questionnaires, either via mail or streamside interview, in an attempt to get direction from clients as to how certain management plans should proceed. Some of these have been highly useful and others have been disasters--usually depending on how well the questions were framed. We have also taken the tack of trying out new management programs and assessing angler reaction ("see who comes to lunch")--this includes catch and release, fly fishing only and trophy lakes. We feel it is important to assess the public's acceptability of a particular program; and if a program is unacceptable to anglers, we must recognize it is not written in stone. We are currently looking hard at limited entry fisheries similar to those for hunting--for example, the isolated Dean River summer steelhead where angler opinion urges us to maintain a wilderness fishery in the face of effort that is increasing at over 15% per year.

With this introduction, we will now consider wild trout management in four categories: large lakes, small lakes, resident stream, and anadromous steelhead and cutthroat fisheries.

LARGE LAKES

We define large lakes as those over 6000 ha. Most of these lakes are receiving no management other than inventory, regulations and constant vigilance by habitat protection staff to ensure that spawning and rearing capacity in tributaries is maintained. Inventory includes physical and biological survey of the lake and its tributaries. Most lakes in the north have not yet even received this level of management. In fact, we have surveyed only 10% of all known water bodies. Regulations are based on our knowledge of both the fishery and the lake's biological capacity. The management of large lakes is often aimed at large fish so a 2 fish over 50 cm daily limit and 4 in possession applies for most lakes.

For certain large lakes, often in the context of major environmental changes such as hydro-electric dams, enhancement mitigation projects have been undertaken to maintain wild stocks. Kootenay and Okanagan Lakes offer good examples.

In 1966, Duncan River, a major kokanee, rainbow and Dolly Varden spawning tributary of Kootenay Lake, was dammed near its mouth by B.C. Hydro. As partial compensation, a 3.2 km long spawning channel was constructed on Meadow Creek, a small tributary to Lardeau River adjacent to the Duncan River. The channel was designed to partially mitigate for up to 2.8 million kokanee for both the popular sport fishery for that species and as forage for the large (up to 15 kg) Kootenay Lake rainbow trout that spawn and rear for one year in the Lardeau and formerly Duncan Rivers. Results have been spectacular in terms of both adult kokanee production and the fact that the Lardeau rainbows are gradually increasing concomitant with modest instream improvement work and stringent catch regulation.

Okanagan Lake has a popular fishery for rainbow to 10 kg as well as kokanee. Most of the large trout spawn in Mission Creek, the largest of 26 tributaries. The productive capacity of Mission Creek has been reduced by channelization, difficult dam passage, and water withdrawal. A program of major stream improvement was prescribed in 1969. Starting with improved passage at an irrigation dam, work in the 1970's has focused on summer and winter maintenance flow and expansion of juvenile living space by the addition of instream cover (boulders).

SMALL LAKES

Of the more than 22,000 lakes in British Columbia, the vast majority qualify as small lakes (under 500 ha). About 800 of the small lakes are planted (400 annually) using eggs taken mainly from wild stock. Close to 150 lakes have been chemically rehabilitated since 1947 and, in combination with fall fingerling and yearling stocking, have created much of the quality rainbow trout fisheries in south central British Columbia. Some limited domestic brood stocks are used to produce catchables for fast developing urban areas (e.g. Vancouver with 1.2 million population). Management of the remaining lakes deals only with natural stocks and again depends on regulation, habitat protection and limited fisheries habitat improvement.

In a growing number of our small lakes wild trout productions are maintained or substantially improved by improving the spawning capability of mostly inlet and some outlet streams. In some cases, this is as simple as stream clearance of debris or beaver dams but in most cases the restoration, addition and maintenance of spawning gravel is necessary. In nine small lake tributaries, we have added gravel--generally in a configuration know as a reverse gravel platform. The public is being gainfully employed in aiding our regional staff in some of these physical activities.

Regulations on small lakes range from the standard 8 fish per day and 16 in possession to 2 and 4, to 1 and 1, to fly fishing only, to electric motors only, to no motors at all.

STREAM RESIDENT FISHERIES

British Columbia is not well endowed with stream fisheries for resident trout. Some quality river fisheries are the Cowichan on Vancouver Island, the upper Dean, the Stellako west of Prince George, the Flathead in east Kootenays, and the Thompson River downstream of Kamloops Lake. The major management techniques are again regulations, habitat protection, and fisheries habitat improvement.

Regulations for resident stream trout range from standard 8 fish a day and 16 in possession, to 4 and 12, to a quota system for brown trout on the Cowichan River, to fly fishing only on the McLeod. Relatively little habitat improvement in nonandromous, resident trout streams has been undertaken but techniques developed and being used for anadromous streams apply.

ANADROMOUS FISHERIES

Steelhead

Angling effort for steelhead is only about 15% of the provincial total, but it is certainly the glamour fish in the eyes of 25,000 licencees. At present with the exception of 3 or 4 rivers, all steelhead management is with wild stocks.

Most anglers think of British Columbia as a haven of bountiful steelhead streams. This is not true. In comparison with Idaho, Washington, Oregon, and Northern California, mother nature dealt us a poor hand when it comes to productive steelhead streams.

Coastal British Columbia was more heavily glaciated than farther south; our streams have higher rainfall and thus more freshets; we have lower temperature regimes; and our streams are shorter and more precipitous. As a result, our steelhead spend one or two more years in fresh water before smolting than do steelhead farther south.

In British Columbia we have over 400 known streams with steelhead but most are biologically unproductive. We have only 4 or 5 large and really productive steelhead streams. Four of those drain our central plateau and are characterized by low rainfall and hard water (high in nutrients): the Dean, the Atnarko of the Bella Coola system, the Thompson below Kamloops Lake, and the Chilko (which we include by a reputation made 20 years ago). Another productive steelhead stream is the Cowichan on Vancouver Island which is in a rainshadow and is lake-headed, so frequent freshetting does not occur to the degree that is common for most other coastal streams.

The current annual catch of steelhead in British Columbia is in the order of 35-50,000 fish: 15-20,000 sport, 15-20,000 commercial and perhaps 5-10,000 Indian food fishery. By comparison the Quillayute system, on Washington's Olympic Penninsula, had a total run of over 20,000 fish in 1977/78. This may be more steelhead than were in all the streams of Vancouver Island last year!

What of the status of our steelhead population?

The federal/provincial Salmonid Enhancement Program (S.E.P.) is aimed at doubling the salmon catch to 50 million fish and more than tripling steelhead abundance in the next 20 to 30 years. That "forgotten fish", the sea-run cutthroat figures strongly in enhancement activities - especially near urban areas. The S.E.P. is one of the largest, most challenging programs of freshwater fisheries development ever undertaken in North America. While the program, which is only in its second year of implementation, is strongly oriented to salmon, it is having a major impact on steelhead management. In three years the Fish and Wildlife Branch has experienced a 10 fold increase in funding for steelhead investigation and production facilities. This largely as a result of a federal commitment aimed at raising our knowledge of steelhead stocks to that of salmon. Steelhead stock assessment work throuout the province is largely complete for the most popular and accessible rivers. Using a variety of techniques, including creel census, radio and nose tagging, electrofishing, snorkeling, trapping, seining and work in the commercial and Indian fisheries, we now know the status of most of our major stocks.

The news is bad. We find far fewer fish in most stocks than we had thought existed. We also find that most stocks are declining. The causes of decline are various combinations of logging, road building, urbanization, water withdrawal, and over-fishing by commercial, Indian and sport fisheries. Considering these factors operate on steelhead which are dependent on naturally unproductive river systems, the low abundance and declining status of our stocks should not be surprising.

It appears that we must live with clearcut logging in coastal British Columbia. Unfortunately moderate to high elevation clear-cutting along the coast may strongly influence rate of snow melt - especially in combination with high winds. Since pre-smolt steelhead spend the winter under large rocks in the stream bottom, any increase in freshet intensity, and thus movement of bottom material will result in increased mortalities and be seriously damaging to the long term abundance of the stock. In addition, any increase in movement of bottom materials in late winter and spring has obvious impact on eggs in the gravel. The bottom line assessment of the steelhead-logging conflict and our message to steelhead anglers is that where there is logging we will have to accept marked decreases in natural steelhead production that can only be compensated by some form of aggressive enhancement.

A major, widely recognized problem with some of our most famous summer steelhead stocks is the commercial salmon net fishery. Summer steelhead stocks in the Fraser and Skeena Rivers, Dean Channel, and Barkley Sound on the west coast of Vancouver Island must run gauntlets of purse seine and gillnet fisheries at the same time as salmon. Although steelhead are legally sold commercially in British Columbia, they are not the target of any commercial fishery. They occur at a very low catch rate ranging from 1 steelhead for every 1600 salmon in

Barkley Sound to 1 in 150 in the Skeena River. The situation is grim in Barkley Sound where, as a result of extremely successful lake fertilization, sockeye salmon are 15 times more abundant than four years ago. We have had to close all streams to the killing of summer steelhead by sport fishermen - it is catch and release only. Included are such well-known streams as the Ash, Stamp and Nahmint.

The solution to this commercial interception problem is difficult. The search for a solution has received the highest initial priority in the Salmonid Enhancement Program. We have worked hard for three years in the commercial fisheries and with the computer. What we have learned so far is not encouraging for a quick solution. This cronic problem of steelhead interception could be accentuated by the enhancement of salmon stocks without adequate consideration of other species and stocks--this is exactly what happened in Barkley Sound when Great Central Lake was fertilized for sockeye and in the Skeena River when spawning channels were built for Babine Lake sockeye. Happily this danger is well recognized by federal and provincial Salmonid Enhancement planners and fishery managers. In mixed stock fisheries, it appears necessary to enhance all stocks and species proportionately or not enhance at all.

This same problem was eased somewhat on the Columbia River by increasing the minimum size of a gill net mesh so more summer steelhead could pass through the chinook nets. Unforrunately in British Columbia, steelhead tend to be larger than the target salmon species - usually sockeye and pink.

Indian food fisheries may be impacting severely on some steelhead stocks--the Chilko is a good example. Indian fisheries are regulated by permit from the federal Fisheries and Marine Service. Together with federal managers we are addressing this problem as it occurs on a river-specific, band-specific basis. However, we have probably seen only the tip of the iceberg of fisheries resource claims by British Columbia Indian peoples.

There is no question that sport fishermen have overfished many stocks. Unfortunately our sport harvest is sometimes just too much on top of environmental damage and inroads by commercial and perhaps Indian fisheries. Good examples are Kispiox, Thompson and Vedder, but we suspect overfishing by sport fishermen is widespread. Stocks that must spend 3, 4 or 5 years as juveniles in unproductive river systems are particularly susceptible to overfishing.

In spite of this doom and gloom British Columbia does offer some superb steelheading. The Dean stands by itself. The Thompson still provides big fish and a good fishing experience. The Skeena River continues to provide good winter fishing in the lower tributaries such as Lakelse and Kalum and late summer-fall fishing in Copper, Kispiox, Babine and Morice. The Squamish still produces large April-May "winter" fish--many to the fly. Vancouver Island still offers reasonable winter steelheading for the persistent angler.

We expect to see a continuing reduction in the allowable <u>kill</u> of <u>wild</u> steelhead by sport fishermen. The day of the "Buffalo Hunter" in British Columbia is over. Wild steelheads are no longer for filling the freezer. Unfortunately, at least in the short run it is the angler who has to be limited even further in his kill--hopefully in the longer run environmental damage can be reversed by enhancement techniques and habitat protection, and commerical and Indian fishery interceptions can be reduced or mitigated. We believe the sport fisherman is largely innocent compared to environmental and net fishing inroads. Although many anglers will be unhappy with further restrictions, we have to avoid a gear war to see who has the "honour" of catching the last wild steelhead.

It is Branch policy that while we may reduce the permitted kill, we strive to maintain the angling opportunity.

Thus we will probably see more catch and release fisheries--at present we have 33 steelhead streams with such regulations for part of the year. We know that the survival of angler caught and released steelhead is very high--even when caught on bait. With catch and release of steelhead it is possible to have your cake and eat it too--but not literally! Our catch and release regulations on the Kispiox, Vedder and Coquihalla have been surprisingly well received, by those who participated. However, participation tends to be reduced by 50 to 75%. Reception has not been as good on Vancouver Island where nearly all summer steelhead streams are catch and release.

We expect to see more gear restrictions such as bait bans and single hooks on wild steelhead streams. We probably will see moves toward more direct forms of limiting the number of anglers on at least a few streams, perhaps by lottery, to maintain a quality angling experience. A system of this type has been in operation for Atlantic Salmon in New Brunswick for many years and is very popular with residents.

At present, stream trout length limits are 20 or 30 cm to protect seaward migrant smolts. We have numerous area closures to protect either spawning steelhead or rearing areas.

The Salmonid Enhancement Program is producing steelhead now, using a wide range of techniques. Instream engineering using boulder, rootwad and log placement to produce more juvenile cover looks promising and is being conducted on 2 streams on Vancouver Island. These developments are founded on work done in the U.S. mid-west in the last two decades. Colonization above impassable falls has substantial potential and is being pursued in 2 projects. Since most of our coastal streams are precipitous, there are hundreds of miles of potential steelhead (and salmon) rearing space above falls. Steelhead from wild stock are being reared in floating pens in two lake/river systems. This technique has wide application and is attractive because it emulates nature and is cheaper than standard hatcheries.

Our steelhead culture program is really just starting. We have consciously taken a "go slow, but produce as you evaluate" approach --a cautious approach because of our concern with disease and genetics questions. In most of our steelhead culture programs only wild fish are used for stock source. Only in certain streams near Vancouver where demand is high and natural production low will hatchery fish be recycled.

Starting this winter, we have particular streams in which it will be permissible to kill marked hatchery fish but unmarked (wild) fish must be released. Those streams have previously been catch and release only.

Unfortunately, producing more steelhead using whatever method, is more expensive and likely to require a longer rearing period than in Oregon and Washington. The reason is the same as for natural production--low temperatures and unproductive water.

Sea-run Cutthroat

Much of the previous steelhead section also applies to sea-run cutthroat. It is a popular estuary and stream fish in coastal British Columbia. In general it spends one or two years in freshwater, spends a summer in or nearby saltwater beaches, returns for the winter to freshwater mainly as immature fish, spends a second year in saltwater, and returns to the stream in late fall to spawn the following spring. Most of the fish entering the fishery are 30-40 cm but individuals over 50 cm occur.

Unfortunately, sea-run populations are down drastically on our south coast. Reasons for this decline are both severe environmental damage to small streams due primarily to logging, water withdrawals and urbanization, and overfishing by anglers.

Management of wild sea-run cutthroat is much like steelhead: habitat protection regulation and fisheries habitat improvement. At present the daily catch is four fish which is a reduction from eight but is probably still too liberal. Length limit of 20 cm for trout in streams protects the juvenile cutthroats as with steelhead.

A major problem for wild cutthroat (as with steelhead and coho salmon) is culvert construction. Substantial effort has been directed at working with the Ministry of Highways, logging companies, and municipalities in improved culvert design and installation and repair of unsatisfactory culverts.

We find that measures to increase the juvenile carrying capacity of small "nutrient rich" urban streams for wild sea-run cutthroat can be extremely successful. In sections of streams where production is judged by biophysical assessment to be limited by lack of appropriate cover (a rather common judgement in our experience), such cover in the form of boulders, logs and root-wads can be added. The life expectancy of these additions is still being assessed but first indications are optimistic. Occasionally spawning gravel is found to be limiting and this situation can be remedied as discussed previously. Special attention is being devoted to guaranteeing minimum summer flow and reduction of fall and winter floods where pratical.

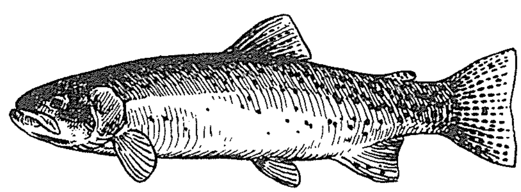
CONSTRAINTS AND THE FUTURE

British Columbia is not endowed with an endless supply of surface water. In fact, it ranks fifth in Canada and barely ahead of the small island province of Newfoundland. The finite water-based resource must compete with a myriad of other water users like irrigation, hydro and mining--doesn't that sound familiar! Although most of our waters are unimpaired they are generally unproductive of presently acceptable gamefish species.

Tourism, the third largest industry after forestry and mining, is often promoted independent of plans for regulated development of fisheries. Just the increased development of access to our water bodies has caused regional resentment of some non-resident anglers, fellow Canadians included. Only opposition by the tourist industry has delayed "resident only" fisheries regulations.

For wild trout to be a reality into the next century, it will cost much more to actively manage fisheries, not just passively protecting habitat and regulating use. There will be a critical need to identify fish stocks and related resources and the means and costs of maintaining and enhancing them. We are still in an enviable position to carry this out, given a more unified voice for recreational fisheries in land use and resource development planning. We have already made a start with some regional lake shore development planning.

In British Columbia there is a saying, "there is no grass beyond the mountains." Similarly, there aren't any wild trout either. The future for wild trout will depend on protection, regulation, and enhancement within integrated resource management. Concurrently, we likely will promote non-salmonids as gamefish and slow down the rate of catch on wild trout stocks.



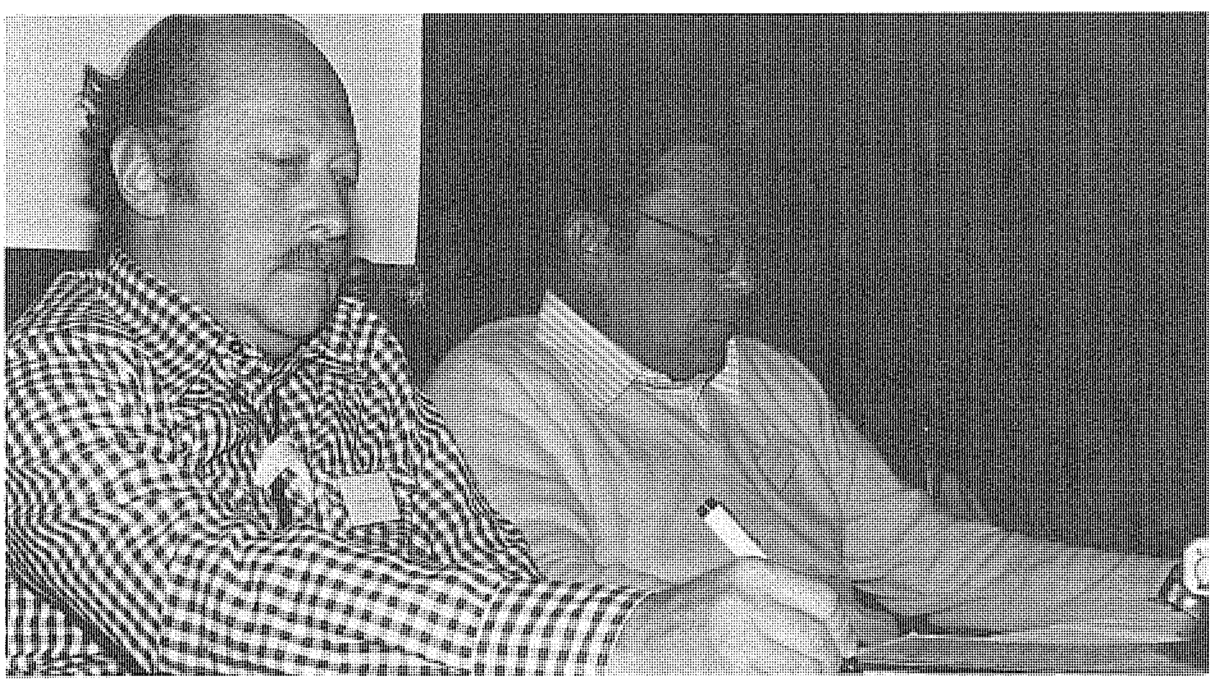
THE CONSTITUENTS PANEL

Discussion Leader

Peter Van Gytenbeek
National Director and
Former Executive Director of Trout Unlimited
Englewood, Colorado

Introduction: This panel's subject is the hardest to circumscribe and present with an attempt at a unified approach. Fishermen are notoriously individualistic, with their pet theories of what makes good fishing, what is good management, and even what lure to use under given conditions.

The panel will present views from the standpoint of the economist, a State wildlife director, the fishing guide, the angler, and from two Government experts. Quite likely, full agreement can never be reached on all details; but our speakers set forth some of the avenues where agreement is most likely, most vital issues, and to tell the public what it can most reasonably expect. Dollars and cents are not the primary concern, rather an esthetic and moral ideal. We should agree on what we can tolerate in trade-offs and compromise. We will see the need for a coordinated approach to solve the many pressing problems, taking into account the numerous factors that have already been considered at this Symposium. It is the responsibility of the people attending this meeting that true values be recognized by the public, by anglers, by our representatives in Government, and yes--by ourselves.



COLORADO'S TROUT MANAGEMENT AND ADMINISTRATIVE OUTLOOK[1]

Jack R. Grieb[2]

Abstract.--Trout management in Colorado as viewed by the Director of the Division of Wildlife. Description of past, present and future management efforts including emphasis on wild trout populations. Importance of participation by fishermen in developing regulations is stressed.

My part of this program will deal with trout management from the viewpoint of an administrator of a state wildlife agency. As Director of the Colorado Division of Wildlife, it is my responsibility to administer a fishery program that meets the needs of all fishermen, coldwater as well as warmwater--bait as well as fly fishermen. In Colorado this is becoming an increasingly difficult task since the population continues to expand and demands of fishermen become more complex and varied.

One example of the changing demand is increasing pressure from organized fishing groups to manage the trout fishery entirely on a wild trout basis and adopt regulations which are designed to provide more and larger fish (particularly the latter).

To further complicate administrative as well as fish management problems, many of the state's streams and rivers have been and are being degraded by channelization, pollution and complete elimination through development of water projects. The habitat base is shrinking! In addition, the Colorado Division of Wildlife, like many state agencies, has an increasing budget problem because of its dependence on license sales, often compounded by a legislature that may not be receptive to sportsmen's needs. Finally, sportsmen are seldom organized enough, nor willing enough to make the effort to influence legislators to protect their resources for the future. There are some exceptions.

Fishing is big business in most western states! In Colorado it is considered one of the state's most important natural resources providing opportunity to about 600,000 resident and nonresident persons. License revenue is about $5 million annually and it pumps over $215 million a year into the state's economy. It is imperative that this resource be properly managed to provide the optimum recreation opportunity for people.

Colorado's management approach includes stocking of catchable and subcatchable trout as well as wild trout programs. These programs are designed and conducted to meet the needs of all anglers young and old, purists as well as worm dunkers. To accomplish this in the best possible fashion, we have developed a "strategic plan" which lists statewide program objectives for warm and coldwater species of fish, and for streams, lakes and reservoirs. Fishery programs are even being developed within the Denver-Metro area around a population of over one million people. This plan requires that the Division develop separate five-year programs which are then broken into annual segments outlining budget and manpower needs. Wild trout management is a part of this plan.

What should be the objectives of a wild trout management program? Some believe they should be to manage wild trout populations within the confines of habitat requirements and to optimize populations of big fish or reduce numbers of small fish. Others feel it should provide a unique fishing experience in a wild stream setting. Obviously, there is no simple answer; instead I see objectives of wild trout management as being diverse for each individual water according to its characteristics and the needs and desires of the fishing public who will use the area. All of this can be enhanced by special regulations such as catch and release to manage certain wild trout populations.

Colorado's first catch and release regulation was established in 1976 on three miles of the South Platte River near Denver. In 1978 another four streams and two lakes were managed with

[1]Paper presented at the Wild Trout II Symposium, Yellowstone National Park, Wyoming, September 24-25, 1979.

[2]Director, Colorado Division of Wildlife, Denver, Colorado.

catch and release regulations. Colorado has nearly 35 miles of wild trout streams under catch and release management. Two specific objectives of the catch and release areas are to improve the opportunity to catch large trout and increase the overall populations of wild trout. In one stream, the objective was to maintain fishing opportunity on a wild population of Rio Grande cutthroat trout which is a threatened species in Colorado.

To evaluate the effect of catch and release regulations, a three-year research program has been designed and implemented. Prior to any further areas being added at this time, we feel it important to determine the impact of this regulation on wild trout populations. Based on preliminary research, it does appear that under certain conditions catch and release management can maintain optimum populations of wild trout under heavy fishing pressure. If, after completion of the ongoing research program it is shown that catch and release does have management benefits then it will be further expanded in Colorado. Plans call for the future establishment of special trophy regulations which will also be carefully evaluated.

It is easy to overlook how much progress has been made over the past years in fish management. As an example, when I first arrived in Colorado over 30 years ago, the fishing season only lasted from mid-May through October and the bag limit was 10 trout. The season is now year-around providing increased recreational opportunity to anglers. In the past there was no fly and lure or catch and release regulations A few spawning closures were about all the wild trout management that existed. We now have 28 separate stream sections where fly and lure restrictions exist in addition to the five streams and two lakes with catch and release regulations. Back in the "good old days" we were forced to operate marginal hatcheries that proved expensive as well as poor fish producers. We have closed these and now only operate those that prove cost effective and good fish producers. Overall, fish management has made tremendous progress in western states and will continue to do so.

There exists in many quarters criticism of hatcheries and catchable trout programs. This is unfortunate and I wonder if it is realized how important our hatcheries are in maintaining fishing opportunities in many waters incapable of supporting wild trout populations. The prime examples are large, fluctuating unproductive reservoirs. In Colorado over 230 reservoirs of 35,000 surface acres are stocked with catchable trout. Without this program there would be strongly reduced fishing opportunity accompanied by a public outcry, political pressure and reduced license sales. Due to budget restrictions there would be less emphasis in programs such as stream improvement and public leases on wild trout streams. I can't emphasize enough the importance of an effectively operated hatchery program in providing fishermen with maximum diversity and opportunity. In Colorado with future plans for massive energy development coupled with more reservoirs and greater population, the need for a strong hatchery system will be even greater.

Another important area is public access. Without it most fishermen will not benefit regardless of how effective the trout management program is. While we are fortunate in Colorado to have a majority of our streams flowing through lands administered by the U.S. Forest Service and the BLM, some of the better fisheries are located in streams flowing through private lands. Because of increased pressure and in some cases outright harassment of private landowners there is a strong trend to "close out" the public from fishing these areas. In recognition of this the Colorado Wildlife Commission has designated cold water stream fishing as their number one priority for fee title acquisition, easement or lease. In my judgment, this is most proper. We must gain control of the better trout waters and we must do it as soon as possible. Future generations will benefit from these decisions. Within the last five years we have acquired access to over 60 miles of trout waters, previously closed to the public.

This brings me to a topic where it all comes together--regulations. Once regulations are established the anglers then take over. Since we manage this resource for people, it is important that the regulations provide the type and kinds of diversity which the fishermen desire within the capabilities of the resource to sustain them.

I have a personal philsophy which says keep the regulations as simple and with the least interference as possible. Naturally, as we attempt to maximize opportunity regulations must become more complicated. This can lead to confusion on the part of some anglers and even breaking the law when they did not intend to do so. The implications of this must be fully understood and evaluated when the regulation is passed.

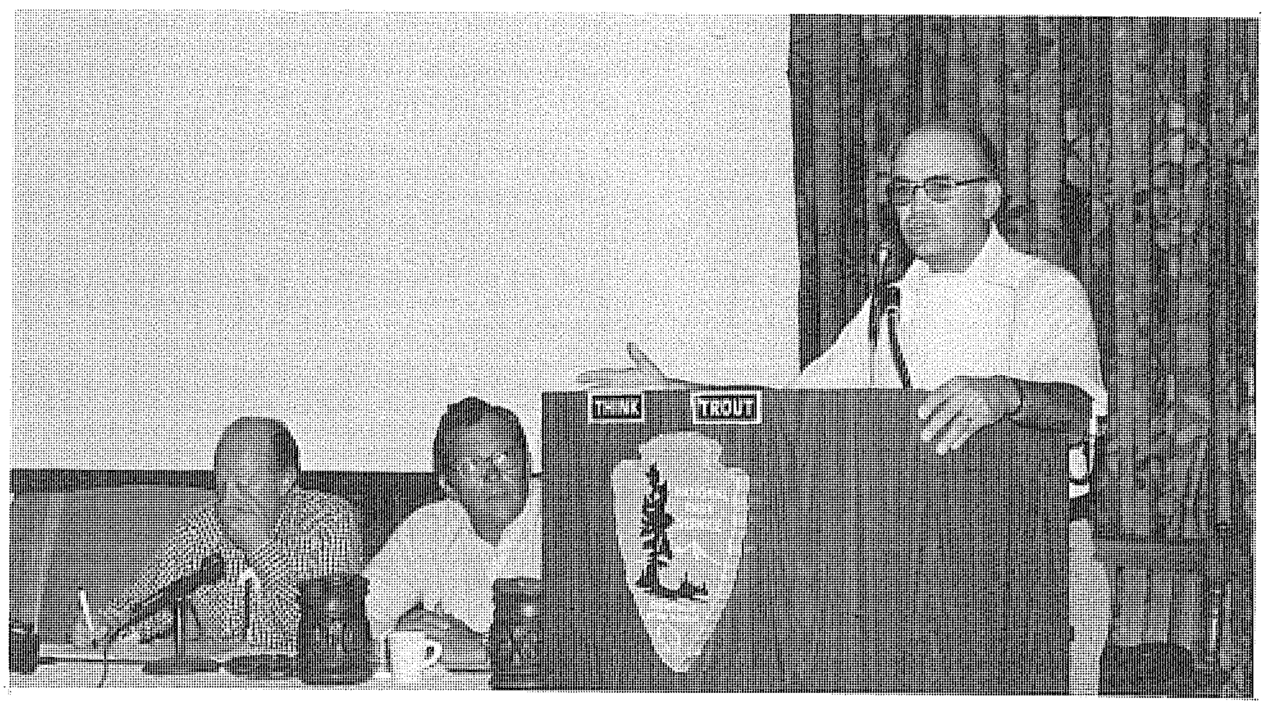
Fishermen should play an active role in establishing fishing harvest regulations. If the staff is doing their jobs, you will be listened to and your recommendations played against the biology of the species and the people management objectives for the particular water or area. The Division and the Commission definitely wants to hear what you have to say and will consider your comments in the final regulation establishment.

Now one last comment which may be the most important of all. The Directors of your states need your support in dealing with their Legislators. Only a few states have control of their own license fees--most must have these appropriated back to them on an annual or biannual basis. The legislative committees responsible for appropriations usually hold hearings and will consider comments from individuals and groups. Find out when these are scheduled and make sure you are represented.

The same is true for introduced legislation which may have a good or bad effect on the wildlife resource. Your state agency will keep you informed if you are interested. Often the only difference between the passage of a "good" bill or the defeat of a bad one is the concern of the groups interested in wildlife matters.

My advice is to be involved to make sure that there will always be wild trout to fish for.

The future of wild trout fishing in Colorado depends on many factors, probably the most important of which is the continued support of all sportsmen. I am confident of their support as well as that the future of wild trout fishing will be good.



TOTAL ANGLING EXPERIENCE[1]

Greg F. Lilly[2]

The future of wild trout fishing in the Yellowstone country (S.W. Montana, S.E. Idaho, and Yellowstone National Park) is of great concern to me. It is of concern not because I am in a fishing-oriented business, but because of my own personal love of the sport of fly fishing for wild trout in one of the most unique and beautiful areas of the world.

The fact that I am in the fishing business (fishing tackle, retail sales and outfitting) was a factor in my being selected to the constituent's panel. Every year I have the opportunity to visit with hundreds of anglers from around the world. This paper is an attempt to share the fears and anxieties, the hopes and the expectations of the anglers with whom I am in contact. This paper will also reflect my own personal opinions. It is not meant to be a documented technical work, but rather an emotional appeal for the preservation of the "Total Angling Experience."

By "Total Angling Experience" I mean an angler has the opportunity to catch a variety of species of wild trout in numbers on a wide range of water types using various fishing techniques in a setting that is aesthetically pleasing. One must, of course, also include the possibility of catching a large trout.

How closely does the Yellowstone country come to providing fishermen with this total experience? Let's look first at the opportunity to catch numbers of wild trout with the potential for a larger trout. This is the domain of the fisheries biologists. Assuming there is no excessive tampering with the stream by man, fisheries managers can control population age class structures in a stream which supports a good population of wild trout, but is subjected to considerable fishing pressure. Numbers and size of trout can be dictated by using selective management techniques such as restrictive angling methods, reduced bag limits, maximum and minimum size limits, or catch and release fishing.

Obviously there are tools that are going to create public controversy. It is not just a biological question as to whether special regulations are applicable to a piece of trout stream, but a matter of social acceptance. There has been a cry from anglers around the world these past few years for more special regulations. However, you do not hear that cry as loudly in Montana, Idaho and Wyoming. Many local people are not really aware of the value of the natural resource of which they are caretakers. They must be educated to appreciate what a tremendous treasure the streams are.

First, the people in the Yellowstone country have to be convinced that open space and undisturbed free-flowing trout streams are almost priceless in exactly that condition. When they are convinced their trout streams are an asset, then they will have to be convinced that special regulations are viable management tools. Already Yellowstone National Park, Montana and Idaho have excellent examples of the way special regulations can work. There is a growing pride in people who use the restricted areas -- a pride that they are a significant factor in maintaining some of the finest quality trout fishing found anywhere in the world. I don't hesitate to tell people that I feel fishing is much better now on streams such as the Madison, Yellowstone and Henry's Fork of the Snake than it was ten or fifteen years ago. Most visiting anglers who have spent many years in the area concur with that opinion. In fact, most people I visit with are in favor of expanded special regulations on not only the Yellowstone country streams, but also on their home trout waters. They hope that the pilot programs which have proven to be so successful in the Yellowstone area will not be the victim of political games, but can be implemented on many other Yellowstone-area streams where it is biologically feasible. It is hoped these regulations can be implemented quickly.

It is not only the attention of the trout fishing world that has turned to the Yellowstone country the past ten years, but the attention of the entire world. Energy needs are directing attention towards the coal deposits along the Yellowstone River. Geothermal, oil and natural gas exploration

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[1] Paper presented at Wild Trout II Symposium, Mammoth, Yellowstone National Park, September 24-25, 1979.

[2] West Yellowstone, Wyoming.

are being vigorously pursued in the Island Park, Idaho region and Hebgen Lake Basin. Should these energy sources be exploited, there would be concomitant industrial development.

A quest for a better quality of life has led to rapidly growing municipalities in the Yellowstone country, and second home development is rapidly shrinking the open spaces of the Big Sky country.

Trout fishing, as was stated in my definition, does not just mean catching a lot of fish or a few big fish. It also means having the chance to escape the normal pace and pressures of life and to enjoy the beautiful serene surroundings through which most of our trout streams flow. It is my feeling that most people who travel to a trout stream do so to reaffirm that they are a part of a natural system, and not entirely slaves to the machine. Unfortunately, the locations where you can discover this combination of harmony with nature and good trout fishing are becoming scarce. The reasons are numerous. As all of us know, the world's energy demands are insatiable. Coal is going to be mined in the Yellowstone country and, it appears, burned on site. This means unimaginable amounts of water will be needed, and the only places that that water can come from are trout streams such as the Yellowstone River. The rivers will be susceptible to damming, dangerously low flows for fish and wildlife survival, pollution and general loss of aesthetic value.

Geothermal development could mean a loss of unique geyser activity and lowered water tables affecting trout stream flows in the Yellowstone area. Oil and gas well drilling could mean additional pollution problems, both environmental and aesthetic.

But the one factor that appears to me to be the most contradictive and ludicrous, and ultimately the most damaging to the "Total Angling Experience," is the penchant people have to obtain recreational home sites or second and third home development in the Yellowstone area. Already the valleys of the famous blue ribbon streams of the Gallatin, Yellowstone and Madison are being slashed into twenty-acre "ranchettes." Why are people obsessed with building "cabins" along all available stream frontage and on the valley floors? Day after day I visit with people who are fed up with city life: the noise, the pollution, the lack of social space - yet they all express a desire to own a home in the Yellowstone country. Ironically, they do not stop to think that what they are doing is bringing those unsavory qualities of city life to the mountain valleys. If second home development continues at its present rate, we are not going to have to worry about preserving our trout streams with special regulations or other management devices. Access to streams will be very limited. Pollution will increase, and angler pressure will be greater on those public places that are available, decreasing the angler's social space. Worst of all, the tremendous experience of fishing a wild natural trout stream will be replaced by the experience of fishing in somebody's backyard with their grudgingly-given permission.

What can be done to insure that the sport of wild trout fishing as we have it today will be preserved for future generations? I haven't any brilliant ideas. The temptation offered by growing real estate values makes it very naive to hope that the resident people who control the stream-front property and adjacent valley properties can be persuaded to resist further development. Perhaps they can be sold on the idea that eventually there will be great value attached to a piece of stream which remains in an undeveloped, natural state. We can hope that means of legislating pieces of stream into a natural status can be established.

The demands of industry, agriculture, energy and municipalities are going to have to be tempered to allow for co-existence of the trout fisheries and the aesthetically pleasing environment in which they exist. This means a sacrifice on the part of some residents as far as dollar gains are concerned. However, to my way of thinking, the gain in peace of mind will far outweigh the monetary gains.

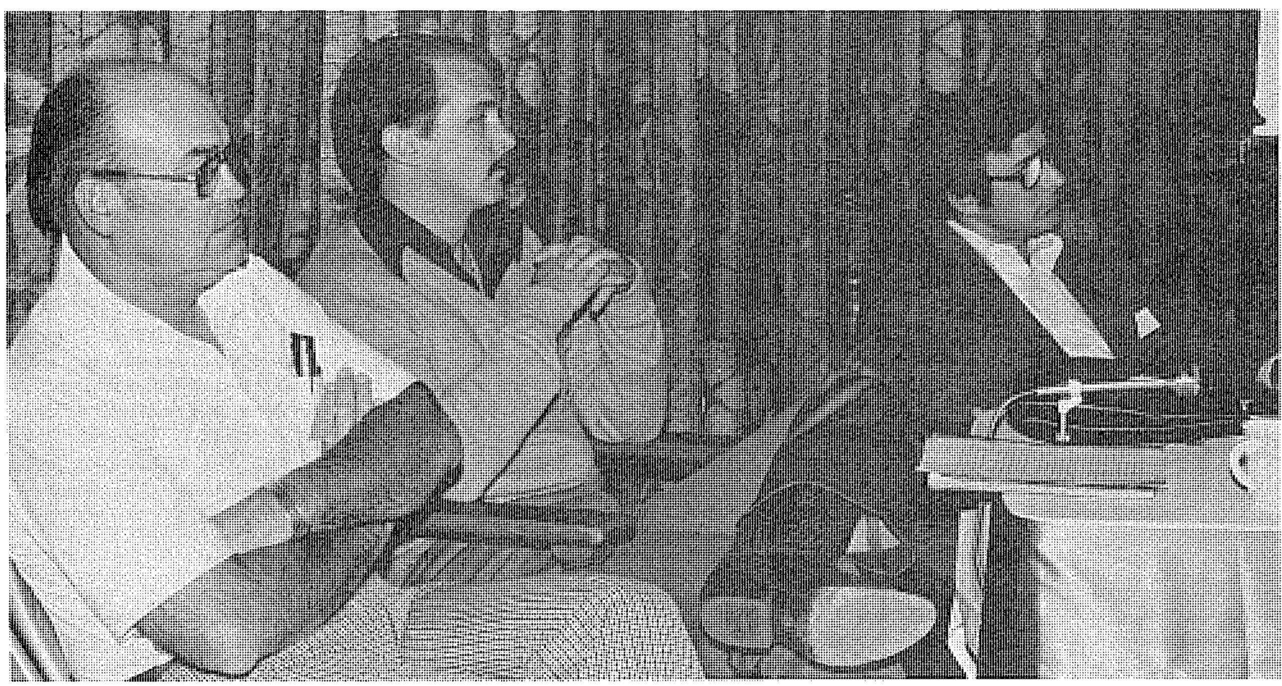
If people can be convinced that the trout fisheries are worth saving in a natural state, then we have to get them to accept special regulations as a way to preserve the quality angling in which most people are interested. They have to understand that trout are a renewable resource and that special regulations do not deny an individual a right, but protects a privilege.

Many people in Montana, Idaho and Wyoming do not know how fortunate they are to be in a position of fighting to save their trout streams and the country through which they run. Other areas of the nation are busy trying to reclaim the fisheries that were ruined years ago.

The education of the local people is the key to preserving the fisheries. It is my feeling that the future of our rivers is directly tied to the quality of life we will enjoy. If the streams remain clean, free-flowing and unmolested, then the independent Western lifestyle most natives boast of still pursuing will be perpetuated. But if the rivers become polluted, impounded, diverted and inaccessible, our lifestyles will evolve along a similar pattern.

It is the responsibility of every government agency whose authority encompasses trout-stream management to attempt to enlighten the people and the politicians to the value of wild trout fisheries in a natural state. Anglers organized into conservation clubs and federations must continue to push wild trout philosophy, but most importantly, every concerned individual fisherman has a tremendous responsibility to convert friends and associates to the idea of wild trout fishing.

Right now it is my conclusion that we still can experience, in the Yellowstone country, what I have called the "Total Angling Experience." Let us hope that our grandchildren can say as much many fishing seasons from now.



AN ANGLER'S VIEW

Martin M. Seldon

Executive Vice President,
Federation of Fly Fishermen, Sunnyvale, CA

ABSTRACT

Mr. Seldon brings together observations from his experiences as an angler and a fishery conservationist. He asks professional societies to support lobbying and emphasizes their responsibilities in Native American Rights issues. Mr. Seldon calls for more balanced management priorities, the preservation of native gene pools and the need for more catch and release programs. He asks that symposium attendees adopt a new logo for this purpose.

INTRODUCTION

As I looked at the professional groupings for this Symposium of research, habitat and management, I felt that our panel of constituents could have much to say in all of these areas. As the representative of the Federation of Fly Fishermen's 50,000 members and in mechanizing their role as the international voice of some 4 million fly fishermen, I find we have many significant ideas to contribute to these disciplines. We ask for funding for streamside buffer zone to protect against logging damage; we ask restoration of the spawning gravels of our streams and rivers; and we ask that the flow management of all water projects be based on year-round fishery needs. In our desire to hand down to future generations what we consider to be magnificent outdoor experiences and the contemplative nature of fishing for wild trout, we ask for both special angling regulations, land use controls, and the preservation of the gene pools of our native fish. What we have not been able to develop is sufficient broad based public acceptance or awareness that would support these values. In plain words, your constituents have done a poor job of getting the political influence necessary to make these things happen.

I would like to present some of the important aspects of what I believe should be emphasized in our quest for enhanced wild trout populations. I would like to suggest that Federal and State agencies must work closely with responsible private conservation oriented fishing groups to promote public education and achieve national political clout for wild trout.

A NATIONAL LOBBY FOR FISH

"Fish Don't Vote - Fishermen Do," is the motto of the American League of Anglers, a valiant group headquartered in Washington, D.C. With a limited staff and dedicated volunteers, the ALA is attempting to represent all of us in the nation's capitol. They are working on wild rivers legislation, a fishing rivers bill, the expansion of the Dingell-Johnson Act, improvement of the Fish and Wildlife Coordination Act, water policy and water quality. All the issues that really need lobbying.

Gardner Grant, a Federation Vice President and an organizer of this symposium, is a Director of the ALA and I am sure he can give you any additional information about the ALA. However, until such time as every sport and professional organization concerned with preserving our fisheries is willing to earmark $1 per year for each of their members to a single organization such as the ALA with the express function of outright lobbying for the fishery resource, we never will have effective representation where it is needed most. I believe that we have approached a time when our professional biological societies must also look at the total picture and become more involved in the political process. You can contribute to lobbying up to the 20% maximum allowed by the Internal Revenue Service. The need is clear and so is the challenge.

COMPROMISE OR FIGHT?

I have heard respected leaders speak of the need for compromise, for reasonable demands and a willingness on the part of conservationists to even horse trade to gain their ends. George F. Grant, our great "River Rat" from Montana, responds to such statements by advising, "We tried to be reasonable in Montana. We compromised, and now we've already lost half the State to developers". I can't help but agree with George. I've seen compromises for expediency where minimum flows below one dam wound up 2 cfs and below another on a larger waterway only

25 cfs. In both cases there was no one to compromise with and no one in government able to get equal protection for the fishery. Political power, lobbying, and tenacity predominate many issues and at present the fish often come out third best. The political compromise on Tellico Dam resulted in a bad project that will destroy much of the trout of the Little Tennessee River.

Even in an attempt to alleviate these problems, to obtain public participation, and pass better laws, the steamroller of the bureaucratic process - government meetings and paper - are now drowning its constituents in an endless morass of hearings, reports, requests for comments and completely unreasonable filing dates. I consider it added gall to be told that I must spend several hours a day reading page after page of the Federal Register to stay on top of what usually is unintelligible legalese that agencies want to use for experiments. Ludwig Von Mises said, "Government is the only institution which can take a valuable commodity like paper and make it worthless by applying ink." The proliferation of more EIR/EIS documents that address all the social problems of our generation will not save our wild trout. We need a better format and more direct results.

Our country has serious urban problems. However, the diversion of Federal Land and Water Conservation funds to build urban parks was not the intent of the fund nor the solution to these problems. Our great wild rivers and remaining wild trout are also a heritage that must be preserved. No EIR or EIS can prorate the value of fish and wildlife for an eternity. If we lose these, man will surely be next.

NATIVE AMERICAN RIGHTS

Although I am neither an American Indian nor an Eskimo, I and many at this Symposium are native Americans from Argentina to the Yukon. Most of us concerned with preserving our fish have also been concerned with the protection of legitimate Indian rights. Many of us have worked to save places like Pyramid Lake in Nevada for the Paiutes as well as the Lake's once fantastic species of Lahontan cutthroat trout. We are still at work attempting to protect the rights of the responsible tribal entities on the Klamath River in California and in doing so, preserve one of the important western steelhead and salmon runs. Unfortunately, greed and ignorance, government capitulation to radicals, a confused judiciary and what sometimes looks like outright corruption, combine to make progress very difficult. With no enforcement on the River, even inadequate regulations are meaningless. We are losing our native gene pools of trout and salmon.

The Northwest Steelheaders invested significant funds in an attempt to obtain protection for the fishery in the courts and they have lost these battles first in the State of Washington and then in Michigan. The courts and the bureaucrats have taken arbitrary positions that are based on the social ills of previous generations. They ignore excessive ocean harvest and excessive inland harvest, combining to destroy most important commercial and recreational fisheries. Whose responsibility is it to provide the accurate resource picture to the courts? Government agencies like NOAA, the Fishery Councils, the State Department, the Bureau of Indian Affairs, commercial fishermen and the water developers can argue for their private interests well past the point of no return. We cannot continue to allow bureaucratic conglomerates such as the Bureau of Indian Affairs to take over the role of the biologist. They are harming the Indians and are destroying our fisheries.

I submit to you representatives of the agencies responsible for the conservation of our fishery resources, that it is your responsibility to keep a true measure of the health of these fragile resources and to insist on safe limits to man's rush to destroy what is most valuable to all of us. From your position you must raise the lantern. Our responsibility is to mobilize the people and the Congress. Perhaps we can find ways to purchase back enough bureaucracy given fishing rights to save the resource for all user groups. With your help, there may still be time.

BALANCED PRIORITIES

In the west, commercial salmon fishing interests and lumber interests have long controlled the power behind many state and local politicians. This has resulted in massive production hatchery operations to produce king salmon fingerlings and a new wave of fish farming experiments. I find it totally unacceptable for the State taxes deducted from my salary to be used as a subsidy for any private profit group.

Similar thought patterns have brought about the large catchable trout concept. I sat in the office of a now retired fish and game official who expounded on the philosophy that, "It is my responsibility to put at least two trout in the creel of every person that buys a fishing license." What rubbish!

As we face squarely into continuing inflation and politicians (some of them even running for President) who stay up nights finding new ways to disenfranchise the sportsmen's license fee dollars, we must demand more balanced priorities. Yes, we need plants of king salmon and steelhead on the west coast. Yes, there is a place for domesticized catchable trout programs. However, these programs must be reduced to reasonable economic limits and the long range needs of habitat restoration, adequate minimum flows and the other basics necesary for preservation of our wild trout must be given equal priority.

We must give the highest possible priority to research in trout genetics and to locating and preserving our remaining pure and wild strains of trout. We have experimented, hybridized and domesticized too long. We must stop the mad rush before it's too late and give emphasis, funding and support to the preservation of our wild trout. We have found that sources of wild trout eggs for programs such as the Federation of Fly Fishermen Whitlock Vibert Box Program that introduces quality salmonids in premium waters, are in disturbingly short supply. I would like to suggest that we are in desperate need of a joint Federal-State program that would locate our remaining stocks of wild trout and establish National Wild Trout Egg Banks. We need programs that will fund small hatchery facilities for small streams that would only propagate indigenous species. Is there any law that prevents large hatcheries from finding innovative ways to produce wild trout? The public is asking for more than cost cutting. We are asking for new priorities and we want them now.

FISHING FOR SPORT

The Federation of Fly Fishermen and many of our friends have long championed angler education and etiquette, the contemplative nature of the sport, and the need to "Limit Your Kill-Don't Kill Your Limit." Ernie Schwiebert often speaks and writes of these values. He first started to understand the catch and release philosophy as a child after having killed a large fish. He fished the same pool for weeks in sadness, never seeing another trout feeding. The realization that the seven and one half pound rainbow trout I released this year near Bristol Bay, Alaska could have been almost ten years old gave meaning to Ernie's words: "There is no ridicule in an empty creel. The seasoned angler counts as his highest reward the fish put back for another day."

In an ongoing survey of fishing regulations and zero limit programs, the Federation recently found in responses from 44 states, four National parks and three Canadian provinces, that there were sixteen zero limit, fishing-for-fun programs under way at the present time. That is a start, but I believe we have a long way to go. If we are to come to grips with the ever expanding number of anglers and the dwindling wild trout populations, we must provide many more "Quality Trout Preserves" and discourage the misbegotten idea that piles of dead fish represent a badge of courage.

I would like to present to you today the basis for positive public education in a way that might help solve some of these problems. The idea is quite simple. It is to develop a broad based general public attitude that is favorable to "Recycling Trout."

RECYCLE YOUR TROUT

Lee Wulff said some time ago, "A game fish is too valuable a resource to be caught only once." Catch and release fishing is on the upswing, but we need your help to popularize the concept. California anglers conceived the idea of developing a logo that could be used internationally to encourage all sport fishermen to release fish. They held a professional competition and after considerable selection and graphic help they finalized a design that should appeal to everyone. The logo was originated by California Trout, Inc., and is being planned for use by Trout Unlimited and the Departments of Fish and Game of California and Colorado. The logo received approval at our recent Federation of Fly Fishermen conclave and we ask that each of you take it back to your individual organizations and agencies and promote its use on your newsletters, stationary, press releases, and other materials that reach the public.

The intent of the logo is to encourage catch and release fishing on a world wide basis and your help is needed to present the idea in a positive manner. Reproduction copies of the logo and release (except for commercial use) is available at no cost from P.O. Box 2046, San Francisco, CA 94126. The Recycle Your Trout concept is appropriate to all types of restricted bag limits. Whether there is a catch and release program or a one or a two fish limit, public support for releasing fish properly should be supported by all of us.

INDIAN FISHING[1]

John D. Hough[2]

Abstract.--A Presidential Task Force was asked to examine the issues surrounding the now famous Judge Boldt Decision. Its findings, although not enthusiastically accepted by Indian or non-Indian fishermen, have become the basis for legislative action to resolve major questions of allocation and jurisdiction over the fishery.

INTRODUCTION

This paper is a summary of the settlement plan that has been prepared by the Regional Team of the Federal Task Force on Washington State Fisheries Problems. The purpose of the settlement plan was to recommend to the national administration and Congress, as well as all interested parties, actions and policies which, if implemented, would provide a set of solutions to the complex salmon and steelhead fisheries problems confronting the Washington State fishery.

The members of the Federal Task Force are: Ms. Anne Wexler, Deputy Under Secretary for Regional Affairs, Department of Commerce (now a member of the White House staff); Mr. Leo Krulitz, Solicitor, Department of the Interior; Mr. James Moorman, Assistant Attorney General, Land and Natural Resources Division, Department of Justice; Mr. Forrest Gerard, Assistant Secretary for Indian Affairs, Department of the Interior; and Mr. Richard Frank, Administrator, National Oceanic and Atmospheric Administration, Department of Commerce.

The members of the Regional Team are: Mr. John C. Merkel, United States Attorney and Chairman of the Regional Team; Dr. Dayton L. Alverson, Director, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, Department of Commerce; and Mr. John D. Hough, Director, Western Field Offices, Department of the Interior.

In developing the settlement plan, the Regional Team has used as its terms of reference the four guidelines established by the Federal Task Force:

1. The optimum utilization of the fisheries resource, including Federal assistance for fisheries enhancement.

2. A healthy commercial and sport fishery that will provide an opportunity for all who depend upon salmon fishing for their livelihood to earn a good living.

3. A utilization of the fishery consistent with recognized treaty fishing rights reserved under the Stevens Treaties of 1854 and 1855.

4. Development of management systems that will ensure that the salmon fishery is preserved and developed so as to satisfy points 1 through 3.

In addition to establishing these terms of reference, the Federal Task Force charged the Regional Team with the responsibility to propose a set of solutions which will have been discussed with, and will have the broadest possible acceptance by, non-treaty sport and commercial fishermen, the tribes, State government, and the Federal government.

The task force was born out of the realization that the fishing controversy in the Northwest was not heading towards some resolution but rather towards increased conflicts: conflicts between the State and Federal courts, conflicts between law enforcement and non-Indian fishermen, and some signs of increasing conflicts between Indian and non-Indian fishermen. Everyone shared a sense of concern and apprehension about the breakdown in law enforcement, the

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[1]Paper presented at the Wild Trout Symposium II, Mammoth, Yellowstone National Park, Wyoming, September 24-25, 1979.

[2]Assistant to the Secretary and Director, Western Field Offices, Office of the Secretary, Department of the Interior, Seattle, Washington.

increased tension and the hostility and the apparent failure of the presently existing management entities under their present authority to cope with the problem. Further, this is a controversy in which each side can lay claim to justice and equity on its side of the issue. For a hundred years the Indians have claimed and attempted to establish that the treaties meant more than simply providing them access to the fishing grounds. In the last decade, the courts generally, and particularly the Federal courts, have accepted that theory and have vindicated the Indian claims. The tribes now take the position that they have utilized the American judicial system to establish the extent of their fishing rights and that these rights should now be honored.

The non-Indian commercial and sports fishermen claim on their side that when they entered the fishery years ago no one informed them that the treaty rights entitled the tribes to fifty percent or more of the fishery, that many of them, like tribal fishermen, come from fishing families and want to continue to fish and do not want to be bought out or to move into another profession. And, finally, they claim that one generation of commercial fishermen are bearing the entire cost of implementing a treaty that benefits the entire population of Western Washington and in a less immediate sense the United States. It became clear that these claims for justice could not both be satisfied under the status quo. Thus, the Administration established a task force with representatives of the three agencies, Commerce, Interior and Justice, who have major responsibilities in the various areas of this controversy. The task force was given the assignment to devise a new set of arrangements under which the principal concerns of each of the affected parties could be accommodated.

In the late spring and early summer of 1977, after assembling our initial staff, the Regional Team held a series of meetings and discussions with representatives of all of the affected parties. These meetings, each of which lasted from three to four hours, were designed to allow the leadership of the affected parties to tell us what they saw as the problems and any possible solutions to those problems.

By midsummer we had completed the first round of discussions with each of the affected parties and several things had become clear. First, that a major staff effort would be required to compile, analyze, and disseminate data and information to all of the affected parties in order that a commonly accepted data base could be created for any future discussions or negotiations. Second, all of the major participants had substantial and deeply felt disagreements in almost every area of the dispute. It was clear that we had a long way to go if there was even to be a chance for an agreed-upon settlement; and that putting all of the participants in face-to-face negotiations at that time would simply have led to further estrangement, bad feelings and no progress towards a solution. In August through September, 1977, the Regional Team and the staff held numerous meetings with representatives of all the groups on various particular subjects and particular problems. Many of these related to the 1977 season when, at one time or another, every major group or institution involved in the salmon fishing season approached us and requested that we investigate this issue. The failure to at least look into the issue would have destroyed our credibility. Therefore, a great deal of time was consumed in issues that were of no long-term consequence but were of short-term consequence to either a tribe, the State of Washington, or the non-Indian fisherman. Also, during this period, we created a technical committee to review the State's and the tribes' enhancement proposals. We chose representatives with biological backgrounds from all of the affected groups to participate on this committee.

Based on these preliminary meetings, discussions and staff work, we requested that the participants submit proposals to us suggesting alternatives or plans for resolving the various critical issues. These were due in early October and every major group involved submitted a proposal of one form or another, ranging from a two- to three-page letter up to an eight-volume submission by the tribes, containing hundreds of pages of alternative proposals. Based on these submissions, we issued a report on the proposals, recommendations and suggestions submitted by all interested parties through November 1, 1977. The paper was organized around eleven topics, ranging from fisheries management to gear regulation to enforcement, resource distribution, etc. Under each topic, the current problems as described by the participants, apparent principles for resolution, and the options posed by each of the participants in our meetings and in their submissions were laid out. This permitted everyone to understand the wide range of aspirations and concerns of the participants in the fisheries. At that time, we reviewed again the desirability of bringing the participants into the face-to-face negotiations and, based on their initial response to the November paper, concluded that such face-to-face negotiations would not be productive at that time. Therefore, the decision was made to set up an intensive round of negotiations between the task force and the participants on a group-by-group basis, using the November paper and our understanding of the viewpoints of parties with different interests as a means of testing possible alternatives on each group. The staff prepared individual gear group and tribal fishing charts which described that group's catch for all species and by each species from 1970 to 1976. This catch data, the proposals that that group had submitted, and the November paper were all used as tools to discuss the various options or possibilities for resolving the major issues. To make the maximum amount of time available for discussion with each group, we decided to utilize a central conference room in Seattle and thereby not waste time in travel or setup or confusion over the location of a meeting place. We were thus able to meet with three to five groups a day with the meetings ranging from two to three and a half hours per meeting. Thus, we not only met separately with each commercial interest and the collective sports representative several times, but were able to meet with individual tribes or treaty areas who had separate and distinct fishery resources and problems.

This round of negotiations continued for approximately a month from early November until late December. From mid-December until early January 1978, we drafted our proposed settlement which was issued in mid-January. The comment period and process was extended by the Cabinet, and so indicated to the parties by Secretary Andrus on a trip to Seattle, in order to permit the parties, the State and the tribes, and ultimately the commercial and sportsfishermen, to engage in face-to-face negotiations to improve upon or find alternatives to our plan. During this period we engaged in an additional round of discussions with anyone who requested such an opportunity to address problems that were specific to a particular area or group of people and to rectify either omissions or the unintended side effects of certain proposals in January. We then incorporated those areas of agreement between the State and the tribes regarding enhancement and enforcement and research and published our final proposal in June of 1978.

We turn now to some specific areas of the plan. It is not our intent in this presentation to discuss the mechanical workings of the plan. Those are set forth in the settlement document. It is rather our intent to discuss some of the thinking and the rationale behind the various proposals.

MANAGEMENT SYSTEM FOR WASHINGTON STATE FISHERIES

We received a number of proposals and recommendations from the State agencies, the tribes and numerous comments from other affected parties regarding what was right and wrong with the present management system and proposals for alternative arrangements. These proposals fell in two groups. The first of which was usually labeled "Single Management Control" and the second which generally fell under the category of "Commission Management." Given the Federal management presence under the 200-mile bill and under the International Pacific Salmon Fisheries Commission (IPSFC), a consolidation into a single management agency would have required Federal management of the fisheries, and consequently the preempting of the State fisheries and game department jurisdiction and tribal jurisdiction. It was evident immediately that this concept was not acceptable to the State agencies, the tribes or the commercial and sportsfishermen. In terms of lesser consolidations, it was unacceptable to the tribes to consolidate the management in the State agencies in light of the past history of those departments, vis-a-vis the Indian fishing rights. It was unacceptable to the commercial fishermen to talk about altering the IPSFC jurisdiction in any way. And it was unacceptable to the sportsmen to consolidate the steelhead management function with the Department of Fisheries. Thus, after the first several rounds of negotiations, it was clear that any consensus decision could not involve a single management entity managing all salmon and steelhead fisheries.

The second concept, that of a commission, was proposed on a number of occasions by various parties, particularly the tribes. This was a concept that was seriously considered and reviewed by the Regional Team. The most successful commission management, that of the IPSFC, occurs where the commission has its own staff free from the biases of either party. The commission and staff make all of the major management and enhancement decisions and essentially only the enforcement and execution are left to the individual parties. This concept would have preempted most of the present State and tribal management functions and was therefore unacceptable to both sides. Thus, we began developing a framework which would provide a system which could maintain the positive benefits of split jurisdiction, namely, open access to information, peer group review and innovation, while at the same time minimizing duplication, overlapping jurisdiction and in-season uncertainty. We proposed procedures requiring the parties to cooperate and resolve differences prior to the fishing season which would maximize the advantages of split jurisdiction and minimize many of the negative features. This was further reinforced by establishing areas or zones of primary management control. For the Federal Government this would be from 3 to 200 miles and in the IPSFC area, the State would manage sportsfishing (for salmon and steelhead) within the 3-mile zone and throughout the State except on reservations, and the State would manage the major portion of the marine net-fishing areas. The Tribal Commission, a new entity managing on behalf of all the tribes, would manage the tribal commercial management zones as laid out in the plan. The plan provides several opportunities for problems to be resolved at the informal level, at the technical level or between the directors of the Department of Fisheries and the Tribal Commission. If that is not possible, then the dissatisfied party may raise the issue to the review board and the review board may indicate, based on the facts, that the agency with the responsibility and accountability appears to be acting correctly or incorrectly. However, the party with the accountability and responsibility may, if it chooses, proceed ahead based on the advice of its own staff. However, in the event that the predictions of the dissatisfied parties turned out to be correct, then the results present a question of good faith to the review board. Should a series of such events re-occur a number of times, there would be a basis for the board to suspend that agency's management functions until such time as it is able to comply with the settlement terms.

SALMON RESOURCE DISTRIBUTION PLAN

Obviously, one of the most controversial elements of the plan is delineating the opportunity to harvest salmon. The commercial and sportsfishermen have responded to our plan by claiming that we provided the Indians with too much opportunity and them with too little. They charge that all we have done is to implement the Boldt Decision in a slightly different format. The tribes on the other hand charge that to accept this plan would be to "surrender" what they have won in the Boldt Decision and that the plan (when compared with the status quo) does not sufficiently guarantee their opportunity to harvest salmon. Our plan was designed to meet the four guidelines laid down by the Federal Task Force. In developing the plan to meet these guidelines, we ultimately settled upon seven principles:

1. <u>The need to protect and develop the salmon resource</u>. The plan assists in accomplishing this objective in several important ways: (1) it establishes a comprehensive State-tribal management regime; (2) the goal of protecting wild stocks is emphasized; (3) a sharing concept is devised to minimize conflict between groups; and (4) the protection of the habitat is stressed.

2. <u>Each group of fishermen must have a fair opportunity to participate in harvesting the surplus fish (in excess of reproductive needs)</u>. Given the amount of different fishing effort which can be applied in various areas, it would be possible for some groups to harvest all or most of the fish available. For example, without adequate control features incorporated into the plan, it would be possible for the ocean commercial and sport fisheries to harvest substantially all of certain stocks at the expense of coastal river, Grays Harbor and Puget Sound commercial and sport fisheries. Puget Sound marine area net fishermen could harvest all or most of certain stocks at the expense of those who fish in the rivers, bays and estuaries. Terminal area fishermen could overharvest stocks needed for spawning escapement. Beneath the competing interests, there exists an interdependent relationship among the fishing groups which governs the economic well being of each group participating in the fishery.

In order to ensure that each group of fishermen has a "fair crack" at the resource, the distribution plan is based on an arrangement which provides fishermen in each area (ocean, inside marine and terminal area) an opportunity to share in the harvest. In addition, because different interests in some cases harvest different species or runs of fish, the resource enhancement projects have been selected on a geographic, as well as species, basis to improve the probability that the various groups will have a fair opportunity to share in the expanded resource.

3. <u>The right to participate and harvest the surplus production should be based on equal opportunity to fish</u>. In the Puget Sound and Grays Harbor net fisheries, disparate fishing times have existed since the Boldt Decision to provide treaty fishermen an opportunity to share in the resource. Our proposal would eliminate the disparate fishing time so that fishermen, fishing in the same area, would fish at the same time and with the same gear. While the elimination of disparate fishing times is an important factor in achieving a lasting settlement, it must be accomplished within a general context of a reduction of the number of commercial fishing vessels and a re-balancing of the remaining fleet between treaty and non-treaty fishermen.

4. <u>The guarantee by the treaty of the opportunity to harvest terminal or special fisheries</u>. Because of historical and cultural ties, many tribal fishermen prefer to harvest salmon in the river mouths, bays and estuaries or certain areas in the Strait of Juan de Fuca. This preference places these fishermen at the "end of the line" in the salmon harvest. All too often in the past, there have been few, if any, remaining fish to be harvested in these places. In order to ensure that these fishermen have an opportunity to share in the resource, this plan provides a guarantee that a sufficient number of harvestable fish will be passed through

the preceding fishing grounds so that these fishermen will have the opportunity to catch a portion of the authorized surplus. (The specific terms of this guarantee are set out in more detail in the settlement plan.)

5. The need for increased stability and resource balance in the opportunities to fish. The fishermen will have a better future with a broader resource base. This may be achieved through a balanced development of species and stocks, including wild and hatchery stocks, and the harvest sharing plan. Some fisheries rely heavily on a few species of salmon, e.g., sport and troll dependence on coho and chinook. Thus, it is important to develop as many stocks as possible. This dependence must also be weighed in the resource sharing plan. In other fisheries which can catch all species, e.g., nets and terminal fisheries, it is important that the present dependence on a few species be altered to broaden the opportunity to take all species. This is important so that all fishery groups will maintain an interest in the care and propagation of each salmon species and stock, i.e., a broad common interest in conservation and enhancement.

Many fishermen have expressed the view, "we need to be able to count on the fishery." All fishermen would prefer a more stable catch year to year.

Improved stability in the fishery is achieved in several ways. The first is through the balance in species and stocks described above. The coordinated management and hatchery development required by the settlement is a key to developing stability. The investment of 10 percent of the settlement money, $20 million, in research will help ensure not only increased production but a more stable and higher quality production. The reduced amount of gear and effort required will be a substantial factor in increasing the stability of seasonal fishing opportunity. The emphasis on more sophisticated harvest management in the ocean fisheries will contribute not only to their stability, but to the stability of the inside fisheries. Finally, the commitment to protect important natural stocks will provide for long term stability of this important source of salmon.

6. Recognition of historic fisheries. Treaty fishermen have fishing rights protected by treaties and Federal law. Non-treaty fishermen have inherited a legacy of participation in the fishery which they wish to enjoy and share with future generations of their families. This resource distribution plan recognizes the desires and interests of both treaty and non-treaty fishermen to share in healthy commercial and sport harvests.

7. Minimize conflict. The remaining principle incorporated into this resource distribution plan is the need to minimize conflict between groups of fishermen. Salmon fisheries have a long history of conflict between various groups. In many respects, the current controversy is a continuation of a pattern which has existed for a long period of time. These conflicts have become so much a part of the industry that the common and overriding interests of all fishermen have taken a back seat and been neglected for years. This will not change until a basic settlement and opportunity system has been agreed to by all major groups. The present potential differences between sportsmen and commercial, between inside and outside fisheries, between North Sound tribes versus South Sound tribes, and area versus area for enhancement dollars would replace the treaty Indian-non-treaty fishing controversies which presently dominate everyone's attention. In order to minimize conflicts, the plan eliminates disparate fishing time and provides specific management zones which will help reduce gear congestion and allow the managers to more effectively exercise control over their fisheries. It also provides a balanced resource enhancement so that every type of fishery will be substantially better than it is today.

In summary, this resource distribution plan is not a simple allocation formula for dividing the salmon resource. It is an attempt, as far as possible, to satisfy the principles stated above. An understanding of these principles will provide a better understanding of concepts and elements of this resource distribution plan.

The principles, as generalizations, do not cover every situation and, in fact, in some situations some of the principles would actually come into conflict. For example, in the outer Straits, the Makahs have historically had a winter troll fishery. Such fishery would fall under Principle 4 by guaranteeing the opportunity for harvest in treaty-terminal or a special fisheries. However, this conflicts with Principle 3, which states that the right to participate and harvest the surplus production should be based on equal opportunity. In situations like this one, we had to weigh the value of the various options available and determine both how important the traditional fishery was to the one side and how detrimental or harmful such a decision would be to other participants or to the resource. In this particular instance, we decided to maintain the traditional fishery while applying certain safeguards or limitations that we felt might be necessary either to protect the interests of others or to protect the resource. We worked with each major party during the course of our negotiations to determine what was necessary or desirable to insure a better future for their people. It is our belief that everyone who fishes after this plan is adopted will be better off in the future than they are today. We further believe that we satisfied the terms of our four goals and the principles discussed earlier in the area of resource distribution.

STEELHEAD RESOURCE DISTRIBUTION PLAN

The steelhead issue was one of the most emotional and difficult issues which confronted us. The sportsmen and many public officials requested that the task force urge the total decommercialization of steelhead and argued instead that we should take a river by river approach discussing the steelhead question with each tribe and attempting to reach a solution on that basis. In their proposals to the task force in October and November of 1977, many tribes indicated a willingness to replace the steelhead fishery with another suitable fishery, but only on the condition that there was no abridgement to their treaty right in terms of a congressional decommercialization bill. We ultimately adopted that approach as our own. Under our plan, the Nisqually and the Puyallup tribes would continue to fish for steelhead. Three tribes, the Quinault, Quileute, and Hoh would continue to fish commercially for steelhead until such time as certain specified salmon returns were available for them to harvest. In the case of three other tribes, the Muckleshoots, the Upper Skagits, and the Lower Elwha, we estimated that returns from the resource distribution and enhancement plan would return earlier than to the aforementioned tribes, but not as quickly as to many others. Therefore, we recommended an interim financial compensation program, in addition to the long-term enhancement and resource distribution benefits of the plan. Through this process, we attempted to weigh the present and future economic dependence and the mixed-stock fisheries problems of the tribes in each river system. Due to the limited number of steelhead and the fact that steelhead are the only major fresh water sport fish in the State of Washington we attempted to replace the steelhead income to a particular tribe with income from a species of salmon and thereby increase the opportunity for sportsmen while not depriving the tribes of income opportunities. While this compromise is difficult for either side to accept, in the long run this will provide the most equitable means of resolving this conflict.

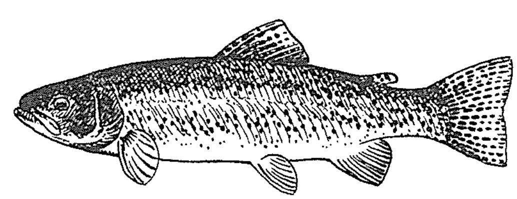
FLEET ADJUSTMENTS, BUY BACK, AND GEAR-UP

These programs were designed to substantially reduce the total number of fishermen licensed to fish commercially within the waters of the State of Washington and off the Washington coast. Second, the program is designed to remove the tremendous excess potential which presently exists in each fleet and which would wipe out the future benefits of the proposed enhancement program to the present fishermen. Third, the proposal provides substantial economic relief for those non-Indian fishermen who wish to retire from the fishery through the buy back program. Fourth, the program provides for an upgrading and modernization of the tribal fleet.

This combination of programs must be reviewed in the light of the need to reduce the overall fishing on the presently existing stocks and as a major tool which we used to set forth the resource distribution plan described earlier.

CONCLUSION

There are no perfect or easy answers to this controversy which has existed for well over a century. We do not believe that the solutions that we have proposed are the only solutions possible. Previously, we had indicated that we would support any resolution of the remaining issues that the participants could agree upon. Unfortunately, they have not been able to agree upon any other alternative schemes.



RECOMMENDATIONS OF THE U.S. FISH AND WILDLIFE SERVICE

TASK FORCE ON FISH RESOURCES OF THE NATIONAL PARK SERVICE[1]

Gordon W. Watson[2]

Abstract.--A Task Force of senior fisheries and research specialists and a National Park Service liaison officer was convened to review and evaluate fishery policies of the National Park Service. Existing policy deals with the act of fishing and not with conservation of fish resources. Based on the Task Force findings, 22 recommendations were made. A proposed policy was drafted with specified long- and short-term goals for all aquatic resources of the National Park System. For natural zones of all NPS units, goals and objectives should emphasize natural functioning of aquatic ecosystems. Elsewhere, fishing programs should emphasize an appreciation of fish resources and the fishing experience.

On April 25, 1978, Assistant Secretary for Fish and Wildlife and Parks, Robert L. Herbst, in a memorandum to the Directors of the U.S. Fish and Wildlife Service (FWS) and the National Park Service (NPS) instructed that an Ad Hoc group of senior fisheries management and research specialists be convened to review and evaluate fisheries policies and operations of the NPS. In addition, the evaluation process would serve to identify how the FWS could best fulfill its functional responsibility to provide its expertise to the NPS regarding fish resource management. The effort would also serve as a pilot model of how the two agencies each might best utilize the knowledge of the other to achieve broader perspectives and encourage cooperative activities in the future.

Mr. Gordon Watson, Special Assistant to the Director, FWS, was appointed Task Force leader; the FWS Assistant Regional Director for Fisheries from each Region and the Chiefs, Office of Fisheries Assistance, and Division of Fisheries Research from the FWS Washington Office comprised the Task Force. Mr. Roger Allin (NPS retired) was appointed by the Director, NPS, to serve in a liaison capacity to the Task Force. Each FWS Region appointed a Regional Work Group of from three to seven fisheries experts to meet with staff members of the NPS and to conduct an on-site review of fish resources management and operational practices at selected units of the National Park System.

Preliminary discussions were held with the Regional Directors or their representatives in each NPS Region; mutual agreement was reached regarding which units of the Park System within the region merited field review. The seven regional work groups visited 34 of the 109 units reported to encompass fish resources.

The posture of the Task Force and Work Groups was to gain an understanding of the National Park Service's management prerogatives and philosophical motivations and at the same time to provide a fresh, unbiased, and critical analysis of the policies, operations and current status of aquatic resource management within the National Park System.

[1]Paper presented at Wild Trout II Symposium, Mammoth, Yellowstone National Park, Wyoming, September 24-25, 1979.

[2]Special Assistant to the Director, U.S. Fish and Wildlife Service, Anchorage, Alaska.

GENERAL

Yellowstone is of particular significance to the National Park concept and the Task Force is appreciative that Mr. Herbst chose this place and occasion to announce our findings and recommendations.

Because the National Park Service will seek public review and comment of the report and its recommendations, it is not necessary to provide the entire report for these proceedings. All recommendations and proposed Aquatic Resource Policy are provided below.

As very brief background, however, the National Park concept was founded in the Act of March 1, 1872, establishing Yellowstone National Park. In that Act, enunciated fundamental purposes were that the Yellowstone country be "set apart as a public park or pleasuring ground for the benefit and enjoyment of the people * * * to be managed * * * for * * * preservation, from injury or spoilation, * * * (and retained) in (its) natural condition."

From that Congressional action (which predated the establishment of the NPS by 44 years), the National Park System has grown to comprise nearly 300[3] areas covering more than 31 million acres located in 49 states, the District of Columbia, Puerto Rico, and the Virgin Islands. These lands total nearly 48,880 square miles, or about 1.3 percent of the total area of the United States (including Alaska and Hawaii).

That the National Park System is a complex system of public lands is a gross understatement (Table 1). Although there are 19 separate classifications of units within the system, there are three basic kinds of units within the system.

Natural areas which encompass national parks, national monuments, wild and scenic rivers, and national preserves; historic and archeological areas including military parks, battlefield sites, and other sites and structures historically associated with persons or events of national significance; and recreation areas which include not only the specifically identified national recreation areas but also national lakeshores, seashore, impoundments, and similar kinds of settings. In each of these three categories, there is often a broad overlap of permitted activity, resource use and national management philosophy.

Although the National Park System by management philosophy is categorized into three major groupings--natural, historical and recreational, the NPS planning process provides that all park lands be zoned into one or more of four land classifications: natural, historic, park development and special use. Each zone in turn may have various sub-zones. Each zone has a primary objective that serves as a guide to the predominant basis of land management in that zone. Thus, resource management policies may vary between each type zone and sub-zone but the management policies and objectives applicable to any zone or sub-zone are the same for all areas of the System (natural, historical or recreational). Variances do occur where legal requirements or valid existing rights require exception by law.

Finally, each unit is subject to one of three types of jurisdiction which is determined by the history of how the United States obtained the land, i.e., the legislation or Executive Order establishing the unit.

Exclusive legislative jurisdiction means that state and local governments have no effective authority to function within the unit. Concurrent jurisdiction permits the joint administration of county, state, and federal regulations and laws in areas under federal administrative control. In cases of conflict the more restrictive regulations would apply, or precedence of authority would shift to the ascending level of government. Proprietary jurisdiction grants NPS the same rights and privileges given any land owner. Additionally, the Park Service is endowed with those special authorities needed to regulate for public safety and health.

Aquatic resources are reported to be found on 109 or 37 percent of the units. Ninety of these units have aquatic resources regarded to be of substantial importance. Commercial fishing is authorized on 20 units. The other two-thirds of the system lack fish-

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[3]The report specifically excludes 13 additional units withdrawn in Alaska on December 1, 1978, under Authority of the Antiquities Act. Because of the uncertainties of Congressional and/or administrative actions in the last quarter of 1978 and early 1979, and because of different potentials and options being considered for Alaska National Interest Lands, the Task Force believed it inappropriate to speculate on these potential NPS units.

Table 1. *Summary of Areas Administered by the National Park Service and those with Fishing Opportunities*

Classification	Number 1/	Acreage 1/	Sport Fishing 2/	Commercial Fishing 2/
National Parks	37	15,619,634.31	30	5
National Monuments	82	9,880,980.09	18	4
National Lakeshores	4	196,678.92	4	1
National Seashores	10	595,211.45	10	8
National Preserves	2	654,550.00	2	
National Recreation Areas	16	3,493,112.51	16	1
National Rivers (includes Wild and Scenic Rivers and Riverways)	6	373,684.91	6	
National Scenic Trail	1	52,034.25	1	
National Parkways	4	159,060.07	4	
National Historic Sites	53	15,050.19	3	
National Memorials	22	6,019.08	3	
National Memoral Park	1	70,408.64	1	
National Historical Parks	18	78,502.19	5	1
National Military Parks	11	34,425.28	3	
National Battlefield Parks	3	6,685.18		
National Battlefields	8	6,611.20	1	
National Battlefield Sites	2	1,801.00		
National Cemeteries		1,616.35		
Parks (Other)	10	31,896.48	2	
Miscellaneous (includes National Capital Parks, National Mall, National Visitor Center and the White House)	4	5,556.63		
Totals	294	31,283,518.73	109	20

1/ From "Index of the National Park System and Affiliated Areas as of June 30, 1977." GPO: 1977-240-955/7

2/ From National Park Service map "Areas with Sport Fishing Opportunities", revised April, 1978

ing opportunities because of the absence of aquatic ecosystems on such units--be it a historic site involving a house and grounds or a national monument of the southwest desert. With the exception of national battlefield parks, national battlefield sites and four miscellaneous units, sport fishing opportunities are represented on at least one of each other type of park unit, i.e., national parks, national battlefields, national seashores, etc.

Fishing has traditionally been permitted by law on each type of unit classification. In the early history of the National Park System, fishing was encouraged. Thus, both public and political support for the fledgling agency was generated. In these early years, management was largely confined to stocking (often with exotic fish)[4] and distribution of fishing efforts to waters that had not yet been exploited. Over time, and as a better understanding and appreciation of ecological considerations and a recognition of the interdependency of other life forms with fish resources emerged, stocking of exotic species was largely discontinued. An effort was made to restore native species and in some instances, to re-establish natural habitat conditions. Also important was the continuing development of a "naturalness concept," particularly in national parks and monuments.

Following World War II, visitation to the parks literally exploded. Concern of park managers and administrators alike changed from how to attract more visitors to how to spread

[4] Exotic fish as used in this report means any species of fish not indigenous to that specific NPS area.

the public-use pressures which had become intolerably high in the more accessible and popular areas. Similarly, how to save, maintain or restore fish resources, which in some places had been adversely affected by both heavy fishing pressures and concomitant developments which accompanied increased use, became matters of management concern.

The total sport fishing effort that presently occurs in the National Park System is unknown. A summary prepared by the NPS for 1975, however, indicates that on 59 areas there were an estimated 5.6 million angler-use days. During that fishing season, total visitor use was in excess of 75.6 million visitor days. Thus about 7.5 percent of visitor use was fishing oriented.

FINDINGS

The Task Force found the existing policy to be generally consistent with concepts of resource and visitor-use of national recreation areas and parts of like areas--national seashores, lakeshores, rivers, preserves and parkways. The policy is regarded as much less consistent with the more restrictive resource and visitor-use concepts for national parks, monuments and historical areas. Current policy is perceived by many Park Service administrators and managers to be contrary to management objectives for internal portions designated as "natural zones" regardless of the type of unit--park, seashore, historical site, etc. Objectives and policies for natural zones generally prohibit removal of both renewable and non-renewable resources.

The present policy was obviously written to cover a wide spectrum of legislative enactments stemming from the original Yellowstone legislation, as well as to encompass the diversity of fishing activities possible within the many-faceted National Park System. The traditional policy has become, however, a "de facto" priority to be accommodated even at the expense of other objectives or purposes and against competing or conflicting uses. We believe acceptance and accommodation of traditional use of fishery resources has contributed to a generally passive aquatic resource program throughout the National Park System. Three observations are presented in support of this conclusion:

1. It is the consensus of the Task Force that, generally, aquatic resources of the National Park System received little attention in terms of direction from the Washington or Regional Offices. Planning is often based on inadequate biological information resulting from limited manpower and minimum funding allocations for research, surveys and inventories related to aquatic resources. Exceptions to this generalization were noted in national parks having above average fishing opportunities for the region and/or conflicting uses for the same waters, shorelines, and riverbanks.

2. Managers generally regarded the existing fishing policy as providing very broad and "needed" flexibility but with a minimum of direction for management of the aquatic resources. Consequently, superintendents or managers tended to passiveness, particularly on areas with joint administrative responsibility.

Park Managers needed to be assured only that state management programs would balance fishing effort with sustainable harvest principles - that fish resources would not become depleted. Thus, a corollary attitude seemed prevalent; that only minimum manpower and funds needed to be allocated for programs that had to be accommodated.

3. On Park System units wherein fisheries are under the exclusive jurisdiction of NPS, fish resources received greater consideration in the objective-setting process and allocation of funds and manpower than on units with joint administrative jurisdiction. Because of specific aquatic resource management responsibilities on areas with exclusive jurisdiction, fishing programs were more often oriented toward a quality experience concept with less emphasis on numbers and size of fish.

Commercial fishing is permitted where authorized by law. The Task Force found several areas where commercial fishing occurs though not specifically authorized. Notwithstanding the legal sanction of commercial fishing within some units, we believe commercial fishing to be an inappropriate activity in the entire National Park System except where it reflects cultural and historical values of the area. We also believe it is a non-conforming use of aquatic resources, particularly when it occurs in natural zones of any type area - natural, historical or recreational.

Discussion

Congress has provided for a system of national parks and other natural areas wherein protection of resources is an overriding consideration; it is a unique ethic of public land management. The National Park System is also the only land system of the Nation whose purpose is to preserve the naturalness of some limited portions of the country. To our knowledge, there are no significant acreages in any other system of public lands, be they state or local parks or reserves, National Forests or National Wildlife Refuges, that mandate naturalness in the same context as the National Park System.

Some federal lands have or will be incorporated into the National Wilderness System, but naturalness is not the same as wilderness although they approximate one another in some aspects. Hunting, fishing and trapping are permitted in wilderness units of National Forests and National Wildlife Refuges if such practices were allowed when the area was designated as a wilderness area. Mechanized means of access for any recreational purpose are usually prohibited within wilderness units. But specific concern for natural functioning of ecosystems is not a singular objective for wilderness areas. We believe it should be a fundamental objective for those units of the wilderness system designated within national parks and monuments, particularly those areas designated as natural zones.

THE TASK FORCE BELIEVES THE LONG-TERM NATIONAL INTEREST WILL BEST BE SERVED BY A REDEDICATION TO THESE STATED PRINCIPLES AND BY ESTABLISHING GOALS, OBJECTIVES AND POLICIES FOR THE NATURAL FUNCTIONING OF AQUATIC ECOSYSTEMS OF NATURAL ZONES.

We believe the first priority for use of fish resources in these zones should be the preservation and maintenance of natural processes. Modification of existing policy will not be easy, nor will it be immediate, and there may be those instances where it will be impossible. It is possible to satisfy the paramount policy objectives without prohibiting fishing. In a few places this is already being done. The Park Service has been a leader in catch-and-release programs wherein mortality is minimized by such means as barbless hooks, artificial lures, etc. This program should be encouraged.

Certain changes will be necessary within the NPS. Aggressive leadership will be required to bring about necessary modifications of existing policy. Strong direction will be needed from the Washington Office. To maintain national consistency in this policy - as in others, exceptions should be granted only by the Director of the National Park Service.

While establishment of objectives for fisheries will reduce managerial flexibility on individual units, we believe the overall integrity of each unit and the entire Park System will be strengthened. Where there is a compelling need to provide for intensive fishery-use programs, unit managers, along with regional offices and the Denver Service Center, should give serious consideration to deletion of such areas from natural zone designation. It might be appropriate to redesignate such portions as special use zones.

In Park System units with exclusive jurisdiction, fishery programs to meet these objectives may be more easily established and implemented than on units with proprietary or concurrent jurisdiction. We believe, however, that the National Park Service has the necessary authorities to establish objectives for fish resources on units with proprietary or concurrent jurisdiction. State management programs should be designed to support national interest objectives.

The Task Force believes that, except for historical or cultural values, commercial fishing should be phased out of natural zones specifically and all other areas generally. We believe the NPS has authority to do this in most areas. Where that authority is lacking, legislative amendments would be appropriate.

To meet these goals and objectives will require development of sound management programs based on adequate and current data. To obtain this data base will require addional funding and manpower for those units with important aquatic ecosystems.

RECOMMENDATIONS

The Task Force made a total of 22 recommendations. Five were on policy, 13 on management and 4 on cooperation with other agencies.

Recommendations for Policy

The Task Force believes the present fishing policy provides NPS unit managers insufficient guidance, particularly in natural area components of the Park System. We further believe this lack of guidance results in a passive attitude that is basically inappropriate for a preservation-mandated and oriented agency. In our view, different objectives are appropriate for the natural, historical/cultural and recreation units of the National Park System, as are objectives for zones within each individual unit. Existing policy fails, however, to provide either long-term management goals relative to fish resources or clearly stated management objectives for their use in diverse areas of the system. We believe the existing policy is too narrowly written and defined and should be broadened to encompass aquatic ecosystems. A broadened and improved policy will reflect both National goals and unit objectives.

The Task Force recommends that:

1. The policy provide both long- and short-term goals and objectives for aquatic resources of the National Park System.

2. Where appropriate, aquatic resource policy be developed as an integral part of overall resource management policy.

3. Latitude should be provided for preservation of unique populations of fish or endangered species in fishless or formerly fishless waters.

4. Where possible, commercial fishing be phased out of park system waters except when it is an appropriate use based on historical or cultural significance.

5. That the PROPOSED NATIONAL PARK SERVICE AQUATIC RESOURCE POLICY drafted by the Task Force be accepted by the NPS. (The proposed policy follows the recommendations.)

Recommendations for Management

The Task Force believes that operational aspects of aquatic resource management can and should be strengthened. Prerequisite to this is strengthening and improving the national policy. Once that has been accomplished, program dollars and assignment of personnel will be required to determine the current status of aquatic resources. We believe research efforts will reveal that problems exist within aquatic ecosystems that have been exploited.

To improve the operational capability of the NPS in carrying out its stewardship responsibilities for aquatic resources of the National Park System, the Task Force recommends that:

6. Each unit of the National Park System having significant aquatic resources either reprogram or seek adequate funds and manpower to update and maintain inventories of those resources. Funds and ceilings will also be required for added NPS Service Center planners and Regional Office supervisory personnel.

7. In park system units with important aquatic ecosystems, management of aquatic resources should be included in the Resource Management Plans. Plans should be developed for all significant aquatic ecosystems and as a minimum, should include goals and objectives for contained resources.

8. The objectives for fishing when authorized in natural zones should be to provide a high quality angling experience in a naturally regulated ecosystem. Elsewhere, fishing programs should emphasize an appreciation of fish resources and the fishing experience.

9. Fishing derbys, tournaments and put-and-take fishing (except in unique urban situations) should be discontinued.

10. The Director, in exceptional circumstances, may provide for preservation of unique populations and/or endangered species in fishless or formerly fishless waters.

11. Stocking of exotic species be permitted only by approval of the Director, following analysis of their probable impact to the aquatic ecosystem.

12. Following appropriate environmental analysis and after consideration of other relevant factors, non-native species appropriate to the well-being of the ecosystem may be declared by the Director, NPS, as "naturalized" and managed as native species.

13. Protection of aquatic resources and enforcement of fishing regulations should receive greater priority in resource management activities.

14. Only state fishery management programs that support NPS goals and objectives for aquatic resources shall be permitted.

15. Policy guidelines should be developed for "habitat restoration" and "habitat improvement."

16. The NPS actively support restoration efforts beyond NPS boundaries that would aid in protection and/or reestablishment of historical native fish populations.

17. Transporting of fishermen, snorkelers, scuba divers and others by charter boats within park units should be closely regulated.

18. Interpretive programs, particularly "in situ", be developed where feasible. Such programs should stress and illustrate the significance of the aquatic ecosystem and its resources.

Recommendations for Cooperation with Other Agencies

The Task Force believes establishment of objectives for management, use, and enjoyment of aquatic resources of the National Park System is the responsibility of the NPS. State agencies should be actively involved in the objective-setting and planning process. The input of affected agencies, private interest organizations and the general public is also necessary.

Once the NPS has accomplished the objective-setting process the Task Force recommends that:

19. Annual meetings be conducted between the NPS and State fishery and administrative personnel to develop frameworks for bilateral cooperative agreements. The FWS and NMFS (where appropriate) should attend such meetings.

20. The FWS be utilized to review the adequacy of State fish management plans for NPS units to assure that Park Service objectives will be supported by proposed State programs.

21. The National Park Service provide adequate funds to obtain FWS expertise on aquatic resource matters. Ceiling allocations should also be agreed upon and formalized in Memoranda of Understanding.

22. Pertinent legislation directly or indirectly influencing aquatic resources should be made available for specific guidance to appropriate park managers.

A PROPOSED NATIONAL PARK SERVICE AQUATIC RESOURCE POLICY

Based on the Task Force findings and recommendations, a proposed policy for aquatic resources was drafted for that agency's consideration. It is as follows:

The challenge facing the National Park Service is to manage aquatic resources as an integral part of the total park ecosystem while providing for the visiting public's continued enjoyment of those resources. The Service will continue the traditional policy of allowing fishing but affirms that aquatic resource programs shall be modified to permit more compatibility with the principles and policies of programs governing other park natural systems. To reach these goals, aquatic resources will be evaluated and administered, when possible, according to the following management priorities:

1. As the first priority, aquatic organisms shall be managed to allow them to fulfill natural functions as predators and prey within the ecosystems.

2. After the first priority has been duly considered, aquatic resources will be managed to satisfy nonconsumptive human needs and uses.

3. After due consideration of the first two priorities and with appropriate management justification, aquatic resources may be made available for consumptive human uses.

4. Existing populations of exotic species may be utilized, reduced, or eliminated, to preserve or restore natural aquatic ecosystems.

Fishing, permitted to meet Park Service management objectives, shall be carried out in accordance with applicable State and Federal laws and regulations. Park regulations may differ for native and non-native species. Regulations may be modified according to NPS objectives for specific aquatic and related ecosystems.

Natural Zones

The primary goal of aquatic resource management programs in natural zones shall be the preservation and restoration of native aquatic ecosystems. This goal will span the entire spectrum of aquatic plant and animal communities plus associated physical and chemical parameters.

A second goal shall be to provide opportunities for visitor enjoyment of the aquatic resource. Such enjoyment shall include viewing and interpretative programs where conditions are suitable. Since most forms of wildlife, including fish, have to be seen or heard to be enjoyed, properly regulated sport fishing, snorkeling and scuba diving will continue to play a significant role in providing for visitor enjoyment and appreciation.

Sport fishing shall be regulated to provide the opportunity for a high quality angling experience. For natural zones, a high quality angling experience is defined as fishing in a naturally regulated ecosystem. Emphasis will not be on numbers or sizes of fish caught, but in the naturalness and appreciation of the total experience. Exotic fish species will not be stocked in natural zones. Stocking of fish may be employed only to reestablish indigenous species.

Waters originally barren of fish will be allowed to revert to their natural state. An exception to this policy may be authorized by the Director when research studies indicate a need to stock threatened or endangered indigenous species in fishless, or formerly fishless waters, if extinction of that fish species would represent a loss to society greater than the loss of a fishless water.

Integrity of natural zones shall be the primary consideration in determining the extent of fishing activity allowed. When there is a compelling need to provide for an intensive fish-use program, modification of natural zone boundaries to exclude the area of use shall be considered.

Historical Zones

The primary goal of aquatic resources management in historical or cultural zones of the National Park System shall be in consonance with historical or cultural themes of the units. Many historic and cultural zones are located within or proximate to metropolitan or urban areas. These zones may provide unique opportunities for visitors to develop an appreciation of aquatic ecosystems not otherwise available to them.

Special Use Zones

Altered natural environments such as reservoirs, tailraces, etc., may reduce populations of some native species and encourage others. New ecological environments and niches are created which may be most successfully filled by exotic species. Native species, however, will be given precedence wherever they are adaptable to altered environments. Rivers and streams may be stocked with exotic species of fish when it has been determined that exotic species are already present and established, and where scientific data indicate introduction of exotics would not seriously diminish native species. Active aquatic management programs shall be developed for such waters to meet NPS objectives. Accordingly, the Service, in cooperation with appropriate management agencies, may develop programs for stocking reservoirs and other waters with exotic or native species, or both for purposes of recreational fishing.

Aquatic Resources Management Plan

An aquatic resources management plan will be developed for each major aquatic ecosystem located within units of the National Park System.

The plan for the management of aquatic resources in the natural areas shall follow the goal for park management as defined by the Leopold committee (1963) which states:

> "As a primary goal, we would recommend that the biotic associations within each park be maintained, or where necessary recreated, as nearly as possible in the condition that prevailed when the area was first visited by the white man. A national park should represent a vignette of primitive America."

The primary objective of aquatic resource management shall be preservation and restoration of native species and aquatic ecosystems for their esthetic, recreational, educational, cultural, and scientific values for present and future generations.

The plan for recreational areas shall follow a goal of appreciation of fish resources, the fishing experience, and fishing skill; not the number or size of fish landed.

The plan should be sufficiently flexible to allow for management of a single or multiple species.

Short-term objectives for aquatic resources management of the National Park System shall be:

1. To determine the current status of each unit's aquatic resources. Current status can apply to entire ecosystems, individual waters, subdivisions of individual waters, or to species or groups of species. It may also be different for two or more species in the same environment.

2. To describe the management option presently in use that best applies to the species, water or ecosystem in question.

3. To select the highest quality management objective for the aquatic resource consistent with the unit's overall resource objective.

4. To design a plan to achieve the desired management objective based on the selected management option.

5. To implement the plan and make every effort to improve the resource status.

Priorities 1 through 4 shall be applicable to commercial fishing. A permit system shall be developed in applicable units to limit numbers of commercial fishermen, boats, and amount of commercial fishing gear. Such permits will not be transferable or replaceable.

The Service also affirms that:

- Waters shall be closed to fishing (or the possession of fish) to protect unique populations of fish and threatened or endangered plant and animal species in park system waters or adjacent habitat.

- Portions of park waters shall be closed to fishing when the fish and other aquatic life have a greater value to the natural ecosystem process, or to a greater number of visitors for appreciation of plant and animal life scientific study, interpretation, or environmental education.

- Fishing will be prohibited in certain waters and at certain times when necessary to protect spawning grounds of native fish species or to maintain natural distributions or densities of native wildlife species that use fish for food.

- Fishing shall be permitted in historic zones when it does not intrude adversely on the historic scene or harm cultural resources.

- In some instances, after consideration of environmental and other appropriate factors, the Director may declare specific species of fish as "naturalized." Upon such declaration, those species will be managed as integral components of the ecosystem.

References

LEOPOLD, A.S. (Chairman), S.A. CAIN, C.M. COTTAM, I.N. GABRIELSON, and T.L. KIMBALL. 1963. Wildlife Management in the National Parks. Appendix D *in* Administrative Policies for Natural Areas of the National Park System, G.P.O., Washington, D.C.

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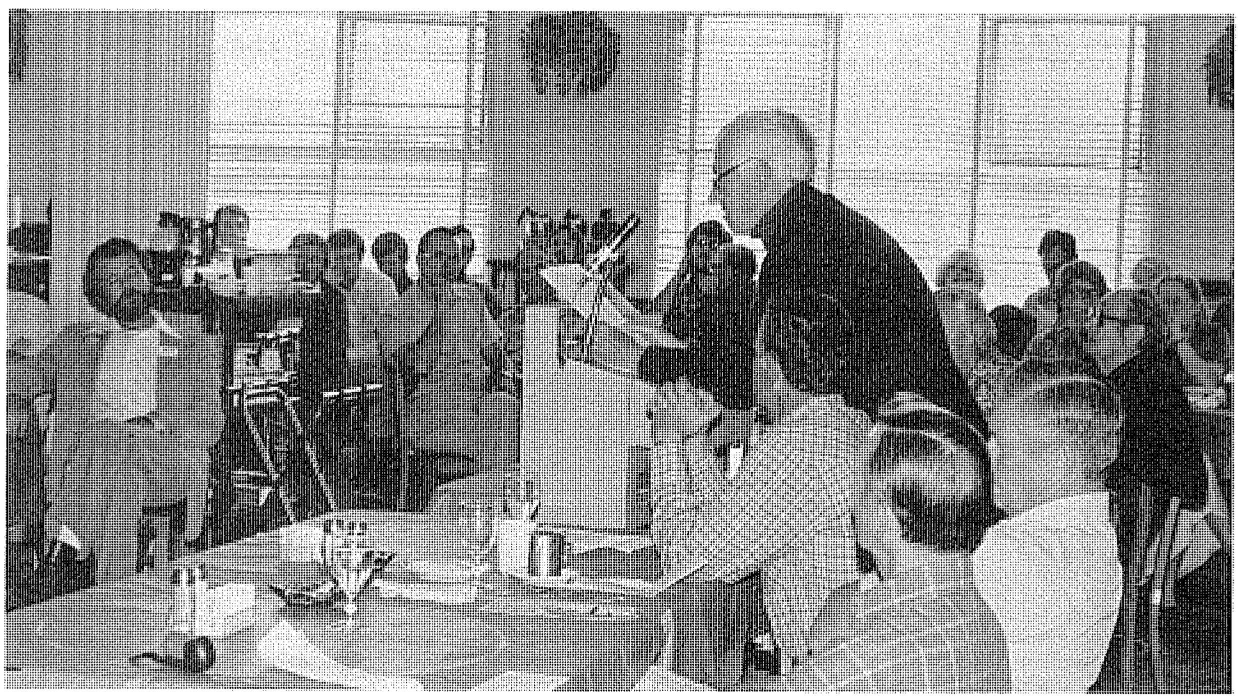
S P E C I A L   S E S S I O N S



THE TROUT FISHING OF THE FUTURE[1]

Lee Wulff[2]

It is one of the great joys of my life that I have lived long enough to see us turn the corner in trout management and know that we are swinging back upward toward great trout fishing in the future. In my youth in Alaska, the supply of fish in our waters seemed endless. It was natural to think that when an angler took a fish out of a stream there would be another like it coming in tomorrow or in next year's run to replace it. As long as we took only a small part of the basic stock, there was some truth to our beliefs. Then the percentage of our cropping increased and we began to change both the abundance and the character of the fish we sought. Only a few of us saw the handwriting on the wall. The consensus was for continuing on a downward course, buoyed up by wishful thinking.

We began making mistakes in management, simple mistakes but of great consequence. As long as we fished for food and kept all we caught, we did not change the genetics of the species appreciably. We had the bright, sentimental idea that if we put the little ones back we would always have plenty of big fish growing up for us to fish for. The thinking was right as far as it went but it didn't go far enough. We established minimum size limits, and eventually we allowed anglers to sort their catch and keep the big ones, while returning the small ones, as long as they stayed within a certain number limit. Had someone asked, "If we cut off the heads of every American over five feet tall for three generations, what would it do to our basketball teams?" we might have done differently. Although every cattle rancher knows it, management did not realize that not all small fish grow up to be large ones, and that by killing off our biggest and best breeders and letting the runts grow and breed, we would dwarf the species. I saw this happen dramatically in many of the untouched streams of northeastern Canada when the great previously inaccessible brook trout waters were opened up by seaplanes. In a few years the size of the fish caught plummeted from a six-pound average down to three or less.

Strangely, this sentimental approach is still with us. In last month's issue of Outdoor Life under the headline "Canada Planning New Lake Trout Limits," the announcement said "regulations that would reduce the lake trout limit minimum size to 10 pounds are being considered . . . the proposed regulations are well founded. Fish in cold northern waters are slow growing, and, unfortunately, it has been the custom for many anglers to take as many fish as possible with no thought to the future."

Researchers have found that in those great lake trout waters of the north, the lake trout were slow growing, that a sixty-pound lake trout may be sixty years old. What does an angler feel like when he catches a sixty-pound lake trout and tosses it into the bottom of the boat to die? That another of the same size will swim in to replace it tomorrow? Does he realize that in all probability he will not live long enough to see a fish grow from egg to that size within his lifetime? Canada should be saving their biggest and best fish to breed and build back this stock they have so drastically depleted.

Once the fish from the shallower, trout-food productive areas of the lake are removed, there are none in the great, cold, deep, foodless expanse of the lake to swim in as replacements. The actual lake trout productive areas of Great Bear Lake are probably less than five percent of its total.

Similarly, the other northern fish tend to move from summer feeding concentrations to winter survival areas. In the great northern brook trout waters, ninety percent of the fish in a river and lake system were concentrated in summer at the lake inlets and outlets. Take out those concentrations and the waters become practically barren of trout. In Maine they learned long ago to restrict fishing near the inlets and outlets of brook trout and landlocked salmon lakes. One would have expected that mature philosophy to prevail in the north as similar fishing developed. Unfortunately, it did not.

"Kill the big cannibals," some of our managers have said, "get them out of the lakes and

[1]Paper presented at the Wild Trout II Symposium, Yellowstone National Park, Wyoming, September 24-25, 1979.

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streams. They eat up all the small fish." Those managers may never have had the opportunity to look at a stream where "nature" has been able to manage for centuries without man's intervention. If they had, they would have found the waters filled to an amazing extent with mature fish. The small fish would be few comparatively and relegated to the poorer feeding areas, because mature fish are generally more efficient feeders and require less food to support a pound of body weight, just as mature humans eat less than their teenage offspring do. The maximum poundage a stream will support will be in the adult form.

We forgot, too, the message of Darwin. Competition weeds out the poorer stock while the best stock of the species survives and prospers. If we did not leave enough spawning stock in the rivers to provide some competition, and if survival was easy, we would develop a weaker stock and less efficient users of the food supply compared with the original stock that had been honed to perfection by hundreds of years of competing.

One of the most amazing "con" games was played on anglers by those managers who said, when anglers complained of poor fishing, "Get out there and fish hard. The waters are 'underfished.' Catch some of them out and the rest will be eager to be caught. Open the season year-round. Take out more trout." So we instituted longer seasons and took out more trout in an effort to improve the fishing.

It is strange, considering that philosophy, that the hermits of the backwoods don't rush down to our hard-fished megalopolitan waters seeking the best in the sport. Instead, what has always seemed true to most of us continues to be true. The best fishing is where the fewest fish have been creeled. The anglers who consider themselves luckiest are those who are able to get back to virgin fishing waters. These waters support the maximum number of large fish.

Another mistake in our management policies has been dealing with angling politically, trying to please as many people as possible and thinking no further than the next election. When a relatively inaccessible pond or stretch of stream which has provided superb fishing for a few hardy souls for a great many years was suddenly opened up by road to hordes of anglers, instead of saying, "The limit on these special waters will be, for example, one fish a day in order to maintain an excellent fish population and give a fair distribution of the sport," they said, "The normal regulations will prevail." With hundreds of anglers taking generous daily limits, in a few years the excellent waters have become quite ordinary.

Behind this is the people-pleasing fallacy that all fishing is of equal value, that the same license fee should cover all fishing waters with, if possible, the same regulations. Ever since the Greeks invented money, it has been the most widely accepted way to put a value on anything. People do not expect a Cadillac for the price of a Volkswagen, and, I am sure, they can understand that certain waters are more valuable for sport fishing than others, and would recognize the fairness of having a higher license fee on the finer waters. The net result of our failure to balance price and quality has been that the fishing hordes abound on the best waters and take out so many fish that they are soon brought down to the lowest possible level. If all cars had to be sold at the price of a Volkswagen, Cadillacs would be like Volkswagens or would disappear. If managers cannot think of sport and monetary value together and make an evaluation, another alternative would have been to divide up the opportunities for quality fishing by lottery which is a more cumbersome and expensive way to accomplish a similar end.

In spite of the great road-building capability and widespread logging that followed World War II, there are still a few relatively inaccessible waters that will become accessible in the future. There is still time to manage these new areas with wisdom. Let us hope we will.

Until about a score of years ago, this Country's basic management goal was MSY or "maximum sustained yield," measured purely in pounds without regard to size and without taking into consideration that an angler who fishes for sport might rather catch one fine trophy fish than a greater total weight of small ones. Only recently did "quality" become a point of consideration in our research.

There were a few breaks in this logic pattern. Earlier, in Maryland, a law was passed to forbid taking stripers over 15 pounds so that the larger fish could remain in the environment to rebuild the average size of the fish in the annual spawning run. There were some other efforts to set up "reverse limits," but it is only in the last decade that they have received serious consideration. It seems now that we have finally seen the light in this regard. Notable examples of the reverse limit are the Railroad Ranch on Henry's Fork of the Snake (keep nothing over 14 inches) and Yellowstone Lake (keep nothing over 13 inches). The practice is spreading, and it is a sign of our maturity in management.

The ultimate tool for the development of quality fishing is the NO-KILL regulation. Beginning with streams in Yellowstone National Park and New York State's Beaverkill, NO-KILL stretches were established and the idea is spreading. NO-KILL means that all the fish possible will remain in the waters to be fished for as long as they live. The NO-KILL waters are crowded compared to the waters under normal management because, logically, people would rather fish where the waters are full of fish than where they are as empty as today's very capable fishermen can make them.

Yellowstone Park's superior fishing rules came from enlightened top management based on good field studies. The Beaverkill and other NO-KILLs in the various states were fought against by many who managed the fisheries, and accepted with reluctance only because of the sheer political clout of the enlightened angling groups like Theodore Gordon/Fly Fishers, Trout Unlimited, the Federation of Fly Fishermen and others.

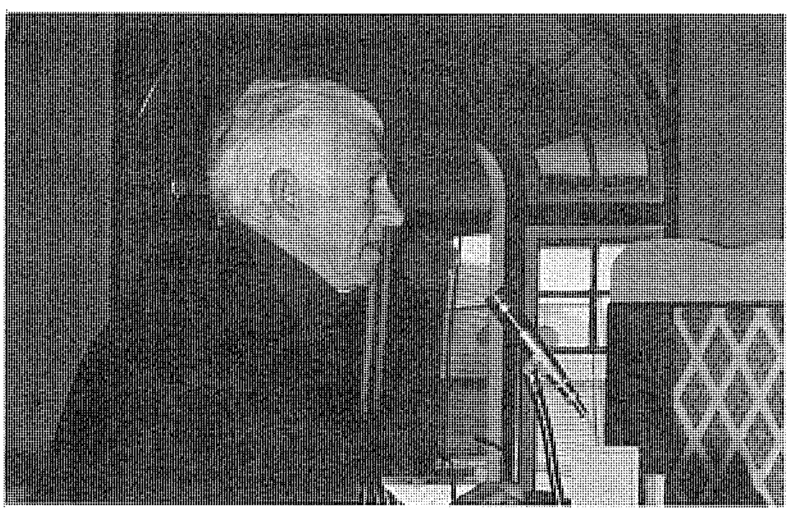
At any rate, we have turned the corner. The NO-KILLs are here to stay. No drawn-out study need be made to determine that when the NO-KILL areas are crowded and the adjacent waters under normal management provide sport for far fewer anglers per acre of water, we need to expand the NO-KILL waters to achieve good and fair use of the resource.

The future brightens when we consider that we will soon be including entire ecological systems under NO-KILL regulations. Then the trout stock will be able to breed and reacquire the particular characteristics most suited to those waters. Only then will we have a true idea of how many trout our great trout streams will hold or how many they held before the white man came, a concept most managers who have never seen waters like those I fished in my youth in Alaska and across the north of our continent, cannot realize. We will have a standard of perfection with which to compare our use of similar waters.

NO-KILL fishing is the top of the trout fishing sport of the future. The trout in such areas, having been caught and released many times, acquire a wariness no wild trout ever had. They offer an angling challenge no old-time wild trout could offer. They will come under your fly and inspect it carefully, measuring the thickness of your leader with a practiced eye, looking for the telltale bend of the hook, for any abnormalities at variance with the real thing.

Because we will have so many more fish in these streams, we will be able to accommodate a great many anglers, each with a skill-testing trout to fish for and another similar fish waiting not far away. The old days of having a great pool on a good public stream all to yourself are gone forever. We have too many fishermen and too few pools.

The difference between the old and the new was brought home to me a few years ago. I had been fishing for big rainbows in the Bristol Bay area of my native Alaska, wading waist deep, casting to the likely spots and consistently finding big, unsophisticated rainbows there to strike my streamers. From there I came directly to the first Wild Trout Symposium in Yellowstone and I fished on the NO-KILL waters of Slough Creek in the Park. It was natural but not wilderness fishing. There were other anglers nearby. In my day of fishing I caught 12 good fish. They were not as big as Alaskan fish, but they were good trout of a 16-inch average length. I took them on flies varying from a great black wooly worm, through several mayfly and grasshopper imitations, down to small midge flies. The catch-and-release trout were far more difficult and far more satisfying to outwit than their Alaskan counterparts. The sport on Slough Creek, the fishing of the future, was better.



WILD TROUT AND CHARR WATCH[1]

H.A. Regier[2] and G. Power[3]

Anglers, naturalists, environmentalists, researchers and managers should jointly create regional wild trout and charr watches to help protect species and stocks from humanity's stresses that are on balance intensifying and expanding. Regional watches could now be initiated for the Rocky Mountain cutthroat complex, the Southern Appalachian brook trout and the Adirondacks brook trout. Others could be started in Canada, Scandinavia, Britain, the Alps, etc. Eventually all might come together in a Nortern Hemispheric co-operative watch.

THE CHALLENGE

"Changes are happening to the habitat and the fish, changes not to anyone's liking, and changes that elude rational control. What's more, those problems are not limited to the Southeast, they span the North American continent, and perhaps the world. Brook trout and related char populations appear to be in trouble." (Argow 1978).

The degradation of salmonid habitats and the suppression and eventual destruction of salmonid stocks in North America may be perceived as occurring in three historic waves. Initial deforestation and breaking of land suitable for agriculture led to a great reduction in the amount of stream habitat suitable for trout, charr and other salmonids. The regions most affected were New England, New France and the Great Lakes basin. There then followed several centuries of very many more localized stresses due to industry, urbanization, overfishing, transportation facilities, etc. These occurred here, there and everywhere over the southern half of our continent. In recent decades a second vast and pervasive stress, something like that of the initial settlement and pioneer development, is intensifying rapidly. Downwind precipitation of the acid wastes from coal and petroleum burning is now destroying lake ecosystems in vast areas that were not yet strongly influenced by direct intensive human use because of their infertile soils, somewhat forbidding climate and geographic remoteness. The waters of these areas were appropriate habitat for uncounted millions of trout, charr and other sensitive species. Many lakes have already become so acidic that no fish species is able to survive in them on a year-round basis; and thousands more will likely fall to acid precipitation during the next two or three decades (Parrott 1979). Many trout waters of Ontario, Quebec and New York State now are subject to precipitation with acid concentrations more than 25 times the normal level (Mount and Rodgers 1979).

All three major waves of human stress still continue - taming of the wilderness through territorial expansion of intensive culture practices; increase in the number and diversity of localized stresses; and increase in the concentration and areal extent of acid precipitation. All the mitigative, restorative, preservative, conservative and related programs have not yet succeeded in reversing the overall trend. Each major deleterious influence sooner or later has a direct catastrophic effect and in addition each entrains long-term chronic influences on any survivors of the catastrophic effects.

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[1]Paper presented at Wild Trout Symposium II, West Yellowstone National Park, September 24-25, 1979.

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[3]Professor of Biology, University of Waterloo, Waterloo, Ont.

Though it is necessary that each major stress agent be separately monitored with a view to its regulation and control, it is not sufficient to stop there. Some critical features of the impacts on ecosystems must also be monitored. Often, and perhaps usually, various human-induced stresses interact synergistically to augment each other's deleterious effects (Rapport and Regier 1979). Ecosystems must somehow adapt to accommodate separate stresses and interacting sets of stresses and there is currently no theoretical substitute for direct monitoring of ecosystem responses. Many persons have recommended that fish, especially salmonids, are very appropriate organisms to monitor for these purposes. They can serve as "miner's canaries" (Argow 1978, Power 1978, Loftus et al. 1978).

WILD TROUT AND CHARR AS INDICATOR SPECIES

The use of indicator species is widespread in surveys relating to the health of natural systems. A particularly apt choice in a campaign to reverse the destructive processes of industrialism would be the salmonines, and particularly charr and other wild, endemic trout. There is widespread recognition of these species and they are broadly attractive in a variety of ways. Thus they are not only useful as indicators of conditions reasonably close to a pristine state of nature, they are also recognized as desirable and valuable in a number of ways. A policy that would conserve the many populations of charr and wild trout, and in particular would prevent the extinction of all recognizably different taxa, should be readily acceptable in the U.S.A. and in other nations across the Northern Hemisphere.

A network of informed scientists together with dedicated environmentalists, naturalists and anglers could develop a continuing Wild Trout and Charr Watch that would seek to produce comprehensive periodic reports of the status of local populations of these species across the hemisphere. In this way, wild trout and charr could serve a role as a miner's canary (also an attractive creature for several reasons) to warn of impending or ongoing destruction for vast areas of northern biomes.

The contents of Balon's (1980) charr book, the proceedings of the Wild Trout Symposia, together with other related literature, demonstrate that our understanding and insights of the various charr forms are now sufficient for purposes of initiating an effective Wild Trout and Charr Watch. Finding funds to initiate regional and international programs along these lines should not be an impossible task. (The above paragraphs are slightly modified from an earlier proposal, Regier (1980).)

The Salmo genus (with the exception of the cutthroat trout complex) has been introduced far more widely around the world than the Salvelinus genus, with the possible exception of the brook or speckled trout Salvelinus fontinalis. Arctic charr have been redistributed relatively infrequently compared to, say, the rainbow trout. We might expect indigenous charr and trout populations to have developed sensitive associations within their native ecosystems and thus be well-integrated into them. This would contribute to their usefulness in serving as indicator species.

CHARR AND CUTTHROAT NEGLECTED, SOMEWHAT

Certain salmonids such as Atlantic salmon and rainbow trout tend to be less sensitive to stresses than charr species, at least when they occur in ecosystems that are naturally less vulnerable to such stresses. The waters may be well buffered against acid response, for example. Nevertheless they have attracted the attention and concern of powerful interest groups of anglers. Such organizations as the Committee for Restoration of Atlantic Salmon and the Atlantic Salmon Association of Canada are examples (Pero 1979). The array of voluntary associations concerned about charr and, say, cutthroat trout is far smaller. The efforts devoted to conserving and rehabilitating Atlantic salmon will clearly have desirable spillover effects for charr and trout interests, but such spillovers are not sufficient to prevent further massive degradation and extinction of charr and trout populations.

R.J. Behnke has for over a decade campaigned to educate researchers, managers and anglers on the neglected cutthroat complex. His information compendia (Behnke 1979) may be sufficiently comprehensive and detailed to provide an adequate basis for creating a regional cutthroat watch. (That sounds like a group of vigilantes!)

ACID PRECIPITATION, CHARR AND WILD TROUT

An understanding of the impact of acid precipitation on salmonids in Scandinavia and in North America has been growing rather steadily during the past two or three decades in spite of very disappointing levels of funding for research directed toward this problem. That the problem was of vast dimensions and of extreme importance was apparent long since, at least to those researchers and managers who had entertained something more than a negligible inclination towards objectivity. Now even the Prime Minister of Canada and the President of the U.S.A. have become aware of it. They are not yet sufficiently concerned to address the problem itself, but they have authorized some quite modest levels of research funding to clarify the problem. Let's hope that the research will not be administered by a rather top-heavy bureaucracy that will act to slow down progress to a nice comfortable walk.

In Ontario waters an understanding of the susceptibility of different populations of lake trout (Salvelinus namaycush) to acid precitation is developing rapidly (Harvey 1979). Meanwhile the rate of acid loading of different waters and the interaction of the acid with the local geological materials are being monitored with increasing accuracy (Parrott 1979, Rodgers and Mount 1979). Provided that modest funding will continue, researchers expect within two years to have quantified some models, e.g. of the risk to lake trout populations of currently expected acid loading regimes, to a predictive stage that will be particularly relevant to management (Harvey 1979). It may take some additional time to reach such a stage with brook trout and arctic charr in Canada, though such understanding will soon be available for the Adirondacks in New York State.

The more modest the funding, the more time it will take to achieve predictive understanding. There appears to be no major methodological or conceptual gap that can restrain progress, - only the usual resistance on the part of those politicians and those senior bureaucrats who would rather not make the necessary commitments.

WHY A "WATCH"?

The word "watch" has come to be used by various scientific groups to refer to programs that transcend jurisdictional boundaries and may involve some voluntary cooperation between different countries or major jurisdictions within a country. The World Weather Watch (IUCN-UNEP-WWF 1979) and the Mussel Watch (Goldberg et al. 1978) are examples.

"Watch" also implies "watchfulness", - a characteristic that is much more likely to dominate an international network of concerned people, including some volunteers, than some hierarchic, segmented bureaucratic agency initiated and administered in a routine, business-as-usual manner.

And there is a certain connotation of militancy that goes with "watch", - as with the Black Watch of Scotland. But militancy need not involve close regimentation, - and certainly should not do so in a Wild Trout and Charr Watch.

We fancy that an international network of sensitive anglers, (Wulff 1979, Schwiebert 1979), knowledgeable do-gooders, committed naturalists and concerned scientists could readily be forged to serve the purposes of a Wild Trout and Charr Watch. Many local populations of these species would be identified for periodic monitoring on a long-term basis. The kinds of data to be collected would be carefully selected beforehand. Data collectors would receive appropriate instruction for sampling, storing and transmitting information to regional centres. The latter would need adequate funding to enter, store, retrieve and summarize the data.

As part of its Natural Heritage program the Tennessee Valley Authority is now using an information collection, storage, access and retrieval system developed by Robert Jenkins of the Nature Conservancy. Perhaps TVA's experiences would be particularly useful in designing regional Wild Trout and Charr Watches, especially with respect to costs and efficiency.

SOPHISTICATED TECHNIQUES

The samples and data to be collected need not be limited to the simplest kinds, such as the relative abundance of different life stages or the length-frequency distributions of samples taken by some specified gear.

Crossman and Casselman (1979a,b) are applying some insights developed by Casselman (1978, in press) in using the cleithrum bones of muskellunge, sent in by taxidermists and anglers, to obtain information on trophy muskellunge. A cleithrum is a bone that supports a pectoral fin. The age can be determined from a cleithrum. Also, using micro-analytical techniques such as electron or ion probes, a record can be obtained of the levels of dosing by various heavy metals that the individual fish experienced during its different years.

Crossman and Casselman (1979a,b) have enlisted the support of Muskies Incorporated and various taxidermists to obtain cleithra. The techniques are not complicated, - a cleithrum is removed from the body, scraped relatively clean with a knife, air dried, and put in an addressed envelope and mailed. The experience of these workers can readily be assessed to provide information on the practical feasibility and approximate costs of incorporating a "cleithrum project" into a wild trout and charr watch.

Perhaps the relevance of obtaining a trace of heavy metal concentrations as a function of age and location deserves further explanation. When acids are loaded into a buffered aquatic ecosystem, the initial contributions of acid are neutralized by carbonates, borates and other similar ions. If these are eventually exhausted, the acidity of the system jumps to a higher level.

New chemical interactions come into play which may involve the removal of aluminium, manganese and other metals from the sand and rock. Some of those metals in ionic form are poisonous to fish but at low levels may become incorporated into the flesh and bones of a fish without killing it. A bone thus serves as an automatic, living monitoring device that maintains records during the life of the fish.

Incidentally J.M. Casselman has accumulated such bones, from the lake trout of Lake Opeongo, that span several decades; he has not yet analyzed them for heavy metal trends. H.H. Harvey states that there appear to be very few useful long-term series of data on the effects of acid loading on lake trout populations.

RELEVANCE TO MANAGEMENT OF STOCKS

The Great Lakes Fishery Commission together with other agencies is organizing a Stocks Symposium (STOCS) for October 1980. The organizer A.H. Berst (1979), has recognized the need for something like the Wild Trout and Charr Watch. He suggested putting together some sort of "catalogue" on salmonid stocks with a listing of all stocks which appear to be genetically discrete. A comprehensive, descriptive account could be produced in a standard format, for each stock. This inventory would extend well beyond provincial boundaries and would require inter-provincial and international cooperation. It would serve to "flag" stocks which are under stresses of various kinds and/or in danger of becoming extinct. Gaps in knowledge of biological or other relevant parameters would immediately become obvious. The inventory would be an invaluable reference for setting management policies and/or developing fisheries management plans based on the stock concept.

The concept of a Wild Trout and Charr Watch will likely be addressed further at the 1980 STOCS Symposium. It would then be heartening to be able to report some tangible progress towards an effective network to watch over these highly desirable species. Symposium participants could be challenged to help design the details of a Watch.

RELATIONSHIP TO INTERNATION PROGRAMS

The proposal of a Wild Trout and Charr Watch is entirely consistent with a strong emphasis on conservation of gene pools and preservation of threatened species and other taxa that emerged from the deliberations of the 1972 Stockholm Conference on the Human Environment (Myers 1976). As it happens, the concerns of the Swedish people about the impact of acid precipitation on their ecosystems, including the deleterious consequences to some salmonid stocks, helped precipitate the 1972 Stockholm Conference in the first place.

D.A. Munro, the Director General of the International Union of the Conservation of Nature and Natural Resources recently commented as follows (Munro 1979):

"I would be particularly interested in hearing more about two activities that were mentioned: char watch ··· and institute watch ···. If you ··· could find the time to put your concepts on paper for me I would be most grateful. I believe that IUCN has the contacts and the mechanism to help activate both these ideas, perhaps the latter especially, and I would be interested in a round of correpsondence with that possible end in view".

A.P. Grima of the University of Toronto is interested in a complementary activity to that of a Wild Trout and Charr Watch, as here proposed, i.e. to monitor how the governments of various jurisdictions respond to the information obtained by the Watch and by other relevent organizations and agencies concerned with these species. Such a proposal for an Institution Watch could readily be developed further once a commitment to a particular kind of Wild Trout and Charr Watch was undertaken.

Both kinds of Watch here proposed are consistent with the "World Conservation Strategy" published jointly by IUCN, the United Nations Environmental Program and the World Wildlife Fund (IUCN-UNEP-WWF 1979). As it stands the freshwater components of that Strategy are developed less fully than is the case with some other kinds of ecosystems. A well-developed Wild Trout and Charr Watch would help to correct this deficiency, especially with respect to the Northern Hemisphere.

CONCLUSION

A Wild Trout and Charr Watch would appear to be a feasible, efficient and effective component of an overall strategy to cope with the increasing threats to the habitat of wild trout and charr populations and species in the Northern Hemisphere. The interests represented at the Wild Trout Symposium II are sufficiently comprehensive and competent to initiate and help to administer such a Watch.

What might eventually become a Watch of hemispheric dimensions might begin more modestly with regional watches. In the U.S.A. it might already be timely to create a Cutthroat Watch in the Rocky Mountain region, a Brook Trout Watch in the Southern Appalachians and a Brook Trout Watch in the American North East. In Ontario a Lake Trout Watch could already be developed. Meanwhile we could contact colleagues in Britain, Scandinavia, the European Alps and the U.S.S.R. and invite them to consider initiating similar programs.

Provided that some progress will occur along the lines suggested here, the leaders of various regional watches might organize an international symposium and workshop to develop an appropriate network for the entire Northern Hemisphere. The International Association of Ecology is planning its Third World Congress of Ecology for 1982 in Europe. That might be a particularly appropriate major event to which to relate the creation of a Northern Hemispheric network of regional wild trout and charr watches.

ACKNOWLEDGEMENTS

In addition to colleagues already named in the text the following have encouraged us and helped us to clarify the proposal: G.C. Armstrong, W.A. Flick, J.S. Griffith Jr., W. King, and C.L. Schofield Jr.

REFERENCES CITED

Argow, Keith A. 1978. Losing ground. *In* Abstracts of Papers Presented at the Brook Trout Workshop, Asheville, N.C., U.S.D.A., Forest Service, Southeastern Forest Experiment Station.

Behnke, R.J. 1979. Monograph of the native trouts of the genus *Salmo* of Western North America. Submitted to USFWS, Denver, CO. 215p.

Berst, A.H. 1979. Letter to H.A. Regier dated Jan. 11, 1979. Maple, Ontario, Ontario Ministry of Natural Resources.

Casselman, J.M. 1978. Calcified tissue and body growth of northern pike, *Esox lucius* Linnaeus. Ph.D., University of Toronto, Toronto, Ontario 782p.

Casselman, J.M. (in press). The esocid cleithrum as an indicator calcified structure. Am. Fish. Soc. Publ. of the N.E. Division Warm Water Fisheries Workshop; The Esocids. p 247-270. (Workshop held in Montebello, Quebec, Oct. 18, 1977.)

Crossman, E.J., and J.M. Casselman. 1979a. The cleithrum aging project. Newsletter of Muskies Incorporated. Vol. 13 No. 7 p 12-17. St Paul, Minnesota.

Crossman, E.J., and J.M. Casselman. 1979b. The cleithrum aging project. Newsletter of Muskies Canada Incorporated. Vo. 1, No. 6, pp3-8. Toronto, Canada*

Goldberg, E.D., and 9 others. 1978. The Mussel Watch. Environmental Conservation 5:101-125.

Harvey, H.H. 1979. Personal communication on Sept. 15, 1979. Toronto: University of Toronto.

Loftus, K.H., M.G. Johnson, and H.A. Regier. 1978. Federal-provincial strategic planning for Ontario fisheries: management strategy for the 1980s. J. Fish. Res. Board Can. 35: 916-927.

IUCN-UNEP-WWF. 1979. A World Conservation Strategy. Morges, Switzerland: International Union for Conservation of Nature and Natural Resources General Assembly Paper GA. 78/9.

Mount, D.I., and G.K. Rodgers (Co-chairmen). 1979. Annual Report of the Great Lakes Science Advisory Board. Windsor, Ontario, International Joint Commission. x + 109p.

Munro, D.A. 1979. Letter to H.A. Regier dated April 5, 1979. Morges, Switzerland, International Union for the Conservation of Nature and Natural Resources.

Myers, N. 1976. An expanded approach to the problem of disappearing species. Science 193:198-202 (16 July 1976).

Parrott, H.C. 1976. Acid precipitation in Ontario. Toronto, Ontario: Ministry of the Environment Special Report. 24pp. (Reproduced).

Pero, T.R. 1979. Saving the salmon - one more time. Trout 20(3):4.

Power, G. 1978. Summary by N.S. Prosser *in* Abstracts of Papers Presented at the Brook Trout Workshop, Asheville, N.C., U.S.D.A., Forest Service, Southeastern Forest Experiment Station.

Rapport, D.J., and H.A. Regier. 1979. An ecological approach to environmental information. Ambio. (in press).

Regier, H.A. 1980. Epilogue: understanding of charrs and the need for a "charr watch". *In* E.J. Balon, editor. Charr Monograph. The Hague: Junk Publ. (in press).

Schwiebert, E. 1979. Angling etiquette: some thoughts on ethics, manners and philosophy. Trout 20(3):16-20, 46-52.

Wulff, L. 1979. Maturity in management. Rod and Reel 1(4):66-68.

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*The Crossman and Casselman initiative using cleithrum bones of muskies is also described, with 14 how-to-do-it photographs, in SFI Bulletin No. 309, October 1979, published by the Sport Fishing Inst., 608-13th Street, N.W., Washington, D.C., 20005

THE ROLE OF NATIONAL PARKS IN WILD TROUT MANAGEMENT[1]

Ronald D. Jones[2]

Abstract.--It is obvious that wild trout habitat is being pressured from every side by the demands of modern society. The National Park System is a natural companion of wild trout management with over 15.6 million acres in national parks, most of which contain aquatic resources of substantial importance. The ecosystem approach to resource management, as is practiced in many areas of the National Park System, assures the highest quality recreational experience. The natural areas of the NPS include high quality and valuable aquatic resources, which are protected by law from spoilation, have the policy direction and management philosophy to provide the public with a high quality aquatic experience for the present and future generations. We must bear in mind that a high quality aquatic experience may or may not include angling.

As we review the state of the art in wild trout management, it becomes apparent that there are ever increasing demands on the habitat required to support wild trout populations. The areas of the country which possess the high quality habitat necessary for wild trout production are being pressed from every side by our technologically advanced society. This same society with its seeming insatiable demands on water for industrial development, irrigation and domestic use, also creates huge demands for quality recreational experiences to relieve the physical and mental stresses produced.

Those of us who are involved or concerned with wild trout management must consider all options for the future. The National Park System is a natural companion of the wild trout movement with nearly 300 areas covering more than 31 million acres located in 49 states. The National Park System is made up of a variety of areas including national parks, monuments, seashores, lakeshores and rivers, historical parks and battlefields. There are 37 national parks containing 15.6 million acres that make up almost 50 percent of the total system acreage. Aquatic resources are found on 109 of the 300 units, with 90 of these having aquatics of substantial importance. The percentage of the aquatic resource sustaining wild trout is unknown, but it is substantial and truly of national importance.

The purpose of natural areas within the National Park System is to perpetuate natural ecosystems in as near pristine conditions as possible for their inspirational, educational, cultural and scientific values for this and future generations. The National Park System is the only land system in the Nation whose purpose is to preserve naturalness. To my knowledge, there are not significant acreages in any other system of public lands, be they state or local parks or reserves, national forests or national wildlife refuges, or the public domain lands of the West, that mandate naturalness in the same context as the National Park System. Although some lands in these systems have been or will be incorporated into the National Wilderness System, naturalness is not the same as wilderness. A wilderness need only be wild and uninhabited by man, while "natural" implies a pristine but dynamic condition where all natural processes are allowed to function relatively unhindered by man's activities. The natural areas of the NPS are protected by law from spoilation and have the policy

[1] Paper presented at the Wild Trout II Symposium, Yellowstone National Park, Wyoming, September 24-25, 1979.

[2] Project Leader, Fishery and Aquatic Management Program; Yellowstone National Park and U.S. Fish and Wildlife Service cooperating.

direction and management philosophies that support naturally regulated ecosystems which often produce the ultimate in wild trout populations.

Fishing has been traditionally permitted in the National Park System since the establishment of Yellowstone and is provided for by law in some parks. Fishing in natural areas of the National Park System is an anomaly in that fish are not afforded the same protection as other forms of wildlife, and is being challenged by some groups for that reason. The future of angling in natural areas may be dependent on making angling more compatible with the total ecosystem approach to natural area management.

There are increasing numbers of people, and a greater proportion of the total population, who derive important satisfaction from seeing nature's processes in action - fish jumping falls, interacting during spawning, rising to a fresh hatch of flies - these and a hundred other instances of natural processes are inspirational moments that live with many observers for a lifetime. The demand for these uses is increasing and must be accommodated.

Fish are not easily visible and angling is a method by which visitors are able to appreciate these resources and the setting in which they occur. The Park Service was an early leader in catch-and-release regulations which emphasize angling as a part of a total ecosystem experience.

The ultimate in quality angling is defined as fishing for native species in a naturally regulated ecosystem with less emphasis on numbers or sizes of fish creeled and more emphasis on the total experience. Therefore, the ecosystem approach to resource management seeks to assure the highest obtainable nature-oriented recreational experience.

Many Park waters contain exotic fish species and in the future, some may be removed and replaced with native species. In many cases, it will never be possible to restore natural conditions because some indigenous fauna may no longer be present. In other areas, it may simply not be within the scope of rationality or feasibility to eliminate exotic populations. In many cases these exotic species are providing the same function in the ecosystem as native species and at the same time provide a quality angling experience.

The naturally regulated populations of both native and exotic fish species are becoming increasingly more valuable as genetic pools for the future. In the natural areas of many National Parks, strict regulations and preservationist management have protected and permitted wild fish populations to continue their evolutionary development relatively unhampered. If it were not for these many areas, wild populations would not exist and there would be many more genotypes on the threatened and endangered list.

The native species in Yellowstone include three subspecies of cutthroat trout, the Montana grayling and mountain whitefish. Yet in the Park there are populations of exotic browns, lake trout and eastern brook trout from single stockings in 1889 that are becoming increasingly valuable genotypes. Many other parks also have valuable populations, such as the eastern brook trout in Great Smoky Mountains and the greenback cutthroat trout in Rocky Mountain National Park. These have been refuges for the sport species of this country, and should be of highest concern in wild trout management today and the future. The National Park System is now and will continue to play an important role in wild trout management. We must realize, however, that parks are created for the benefit and enjoyment of the people. This means that these protected areas are to be shared by all the people. People's enjoyment is a dynamic thing and with better education, more leisure time and more mobility there is a growing demand for a wider variety of experiences. Special interest groups, such as bird watchers, boaters, several angling groups, protectionists and many others, compete in the use of aquatic resources of parks.

In order to meet the demands of all the special interest groups and preserve the resources in any semblance of a natural condition, it is going to require special magic on the part of managing agencies. There is no room for single, double or triple purpose thinking. It must be multipurpose. We must intermesh the diversity of the natural system with the diverse demands of the visiting public. All user groups must realize that all the prime aquatic resources suitable for their special uses will not be available to them for that use. We must also prepare ourselves for the fact that in the future, we may not be able to use our favorite area as often as we would like in order to protect what we value. Naturalness can be loved to death.

CATCH-AND-RELEASE FISHING IN YELLOWSTONE PARK[1]

John D. Varley[2]

Abstract.--Sportfishing on seven waters having catch-and-release regulations for up to nine years have displayed varying results. In years following the change, angler use has ranged from modest increases to a 92% decline. Trout catch rates, the number of anglers catching one or more trout, and trout sizes have generally improved although different species react in different ways. Cutthroat and rainbow trout appear to be significantly better suited to C&R regulations than brown and, perhaps, brook trout.

Catch-and-release fishing in Yellowstone Park had its beginnings in the early 1970's although groundwork for change had been laid at least a decade before. In a way, the catch-and-release only (C&R) concept was the natural culmination of a 100 year series of events that began with unlimited fishing (and unlimited keeping) and which with each new, increased level of use saw a new more restrictive regulation. The planting of hatchery fish may have helped in the early years but eventually the demand was greater than the supply. Such was the pattern of use in the Park, slowly, steadily increasing until use inevitably became overuse.

To tell the whole story, we would need to look at the two main guiding objectives, an aquatic (or fish population) objective and a sportfishing objective. The aquatic objective sought to cure the problem of overuse principally on highly used roadside streams. Because of the preservationist philosophy of management for Natural Areas within the National Park System, there was a further impetus to allow native fishes in natural environments to return to a facsimile of their historic densities and age-size population structure.

[1]Paper presented at Wild Trout II Symposium, Yellowstone National Park, Wyoming, September 24-25, 1979.

[2]Fishery Management Biologist, Yellowstone National Park and U.S. Fish and Wildlife Service cooperating.

The sportfishing objective aimed toward the kind of fishing in the kind of setting that must have occurred in the late 1800's, when modern man first visited the Yellowstone area. Even fishing termed excellent or superb today would pale under the catch rates experienced and the sizes of indigenous trout caught by those fortunate pioneer anglers.

The only significant prerequisites for the shift to catch-and-release fishing were the prohibition of all bait fishing and a base of political and public support. The bait prohibition was the more difficult of the two because it discriminated against children. The political-public support was generously provided by organized fishing organizations.

Most fisheries chosen for C&R in 1973 were roadside streams. From a research standpoint, most are poor choices because there are few prior statistical data available. The Yellowstone and Lewis Rivers were largely tourist-oriented waters. The Yellowstone River is pure cutthroat trout and the Lewis River is a brown-brook trout fishery. The clientele of the Lamar River and Slough Creek are more oriented towards experienced, often locally based fishermen. Both streams have cutthroat trout in the upper portions and cutthroat, rainbow and hybrids of the two species in the lower reaches.

Three other fisheries that I will treat briefly are back-country (3-8 miles from a road) lakes. Heart Lake has a cutthroat trout, lake trout, and mountain whitefish fishery that became C&R for cutthroat (only) in 1974, with a two fish daily limit allowed for the two other species. McBride Lake is a cutthroat fishery adjacent to Slough Creek that was included in the 1973 C&R regulation changes. Grebe Lake is a fishery of predominately Montana grayling although some cutthroat x rainbow hybrids also occur. Montana grayling became C&R in 1969, although on Grebe Lake the hybrids can be harvested at a rate of two per day.

From our experience, the effect of catch-and-release fishing on angling use is not very predictable. For instance, if we compared three C&R lakes to that which occurred in terms of parkwide angler-days, we would have the following results (fig. 1). McBride Lake, which is the only lake illustrated that is wholly C&R, may only sustain 8% of its pre-C&R level of use. Angling activity in recent years appears to be both low and stable despite a generally increasing pattern of use parkwide.

On Heart Lake, where approximately 50% of the trout caught are cutthroats and must be returned to the lake, use in the 1970's appears to be much less than was estimated during the 1960's. Unlike each of the other C&R waters, use actually increased the first year it became a C&R fishery although it appears to be in a generally declining trend since 1974, quite unlike the parkwide trend.

When Grebe Lake's grayling population went to C&R in 1969, use appeared to have dropped from estimates taken in the 1950's and appears also to have had a declining pattern since 1973.

Comparing four large roadside streams with the same parkwide angler-day data, results are mixed (fig. 2). Prior to 1973, the heavily used 9 mile section of the Yellowstone River sustained between 40,000 and 50,000 angler-days in about a 45 day period. The first year of C&R angler use dropped by 44%, although not all of the loss can be attributed to the regulation change because of the general parkwide decline in use from 1972-74. From 1974 through 1976, the fishery appeared to be gaining back much of its popularity coincident with increases in parkwide use, but this was followed by two successive decreases in 1977-78.

Although the angling use pattern on Slough Creek bears a superficial resemblance to the pattern of parkwide angler-days, this fishery also lost a significant number of angler-days the initial year; however, following six years of C&R, use is back up to the levels observed in years immediately preceeding the regulation change (fig. 2).

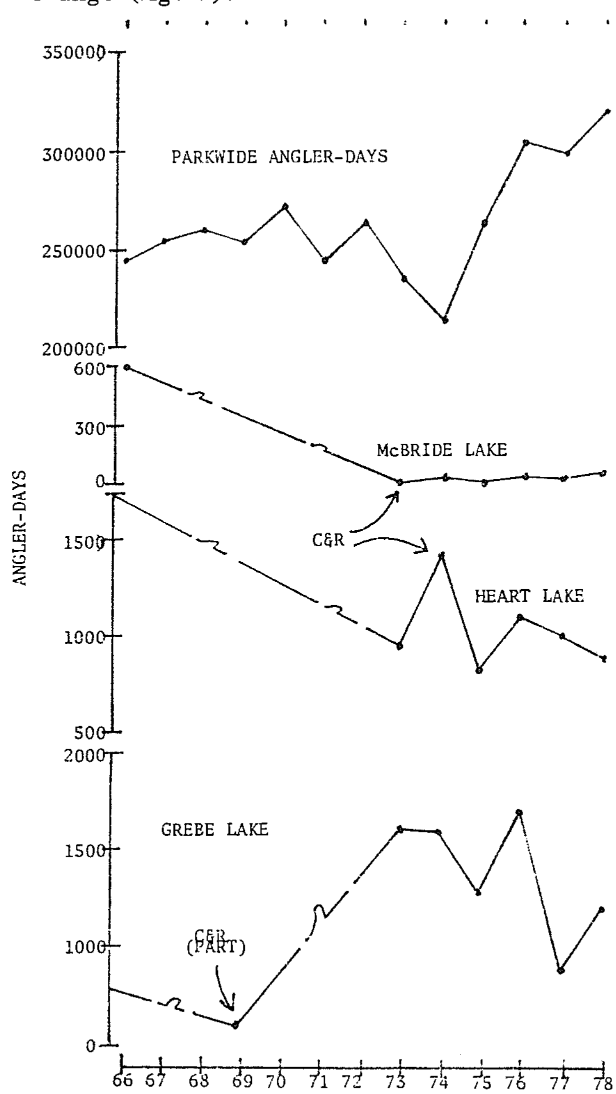


Figure 1.--Parkwide angler-day use compared with three C&R lakes.

For the Lamar River, there are little data available prior to 1973, although it could be assumed that the use estimated in 1973 was a decline from the previous year (fig. 2). Whether the upward trend in use observed since 1973 is a "come-back", or whether it is new-found popularity may be immaterial since biologists tagged it as a "mediocre to poor" fishery in 1966. If true, there have been significant changes in recent years.

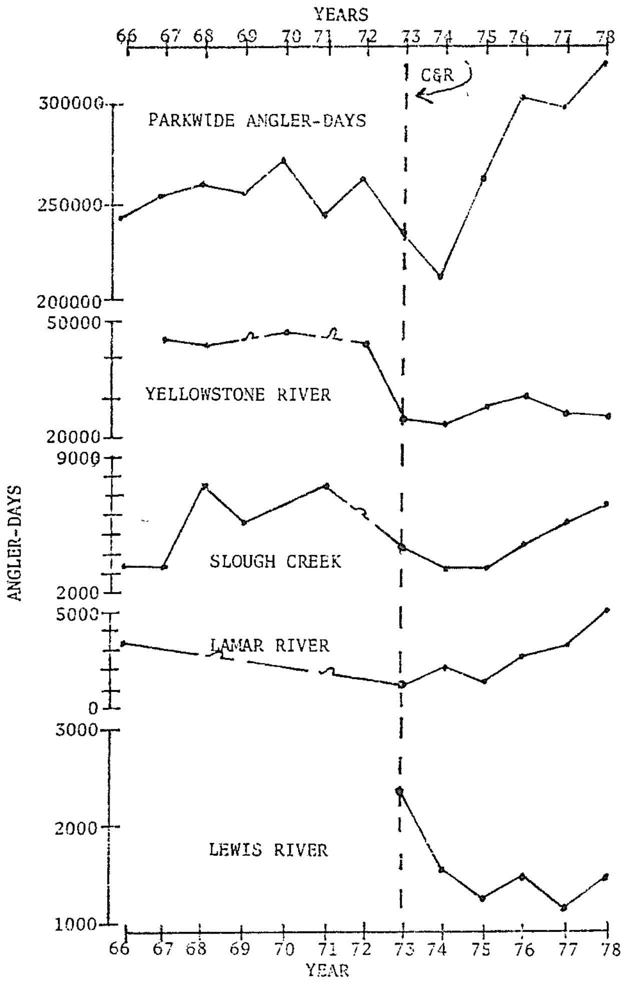


Figure 2.--A comparison of Parkwide angler-days and four Catch-and-Release streams in recent years.

The Lewis River catch-and-release area gives a different view. There are no data from before 1973, but the pattern since appears conclusive; three years of steep decline followed by what I interpret as low stability. It may be a pattern most closely related to that observed on the Yellowstone River (fig. 2).

Trout catch, or the number of landings per day, is one of the significant measures of angling success. Information obtained from the four streams that went to C&R in 1973 was compared to a composite of six other streams whose regulations did not change. All C&R streams showed some improvement in catch that could be attributed to the regulations (fig. 3). Some of the variation illustrated for the first three years (1973-75) may be due to small sample sizes, sampling design, or other factors, although improvements seem to be conclusive. The degree of improvement, however, varies widely.

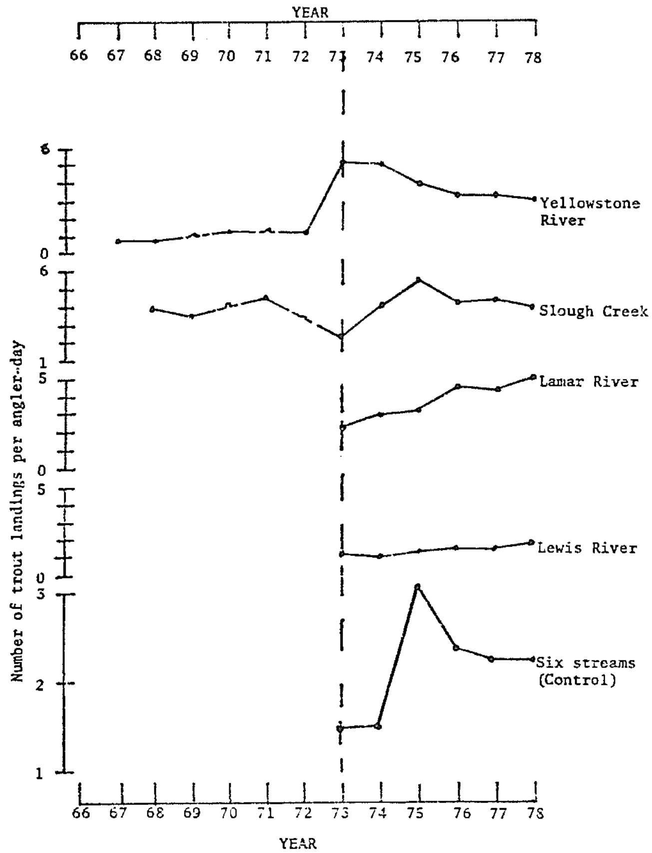


Figure 3.--Trout landings per angler-day on four streams that became Catch-and-Release in 1973, and six similar streams that remained unchanged with regard to regulations.

In the last three years (1976-78), the Yellowstone River has averaged about 3.4 trout landed per daily trip which is roughly 65% greater than before C&R. Conversely, Slough Creek, after the first year of C&R being the worst year on record, recovered although it has apparently only improved about 5%. Proponents of C&R fishing would always like a Lamar River - a steady increase over the six year period from 2.5 trout/trip to 5 trout/trip - a solid 100% increase in angling success. Although not as spectacular, the Lewis River showed a steady improvement in success resulting in about a 39% increase.

Results on the change in average size of trout landed is somewhat more conclusive. The average size represented by the control streams has varied and may have even declined (fig. 4). With the exception of the Lewis River, whose trend bears some resemblance to the control, the other three streams show a pattern of greater average sizes. The average size of trout in the Yellowstone River increased from 14.3 inches to 15.1 inches. Trout in Slough Creek increased from 11.5 inches to 12.9 inches and fish from the Lamar River from 10.8 inches to 12.6 inches. Conversely, the average size of combined brown and brook trout from the Lewis River showed some increase in the early years but has been declining since 1975.

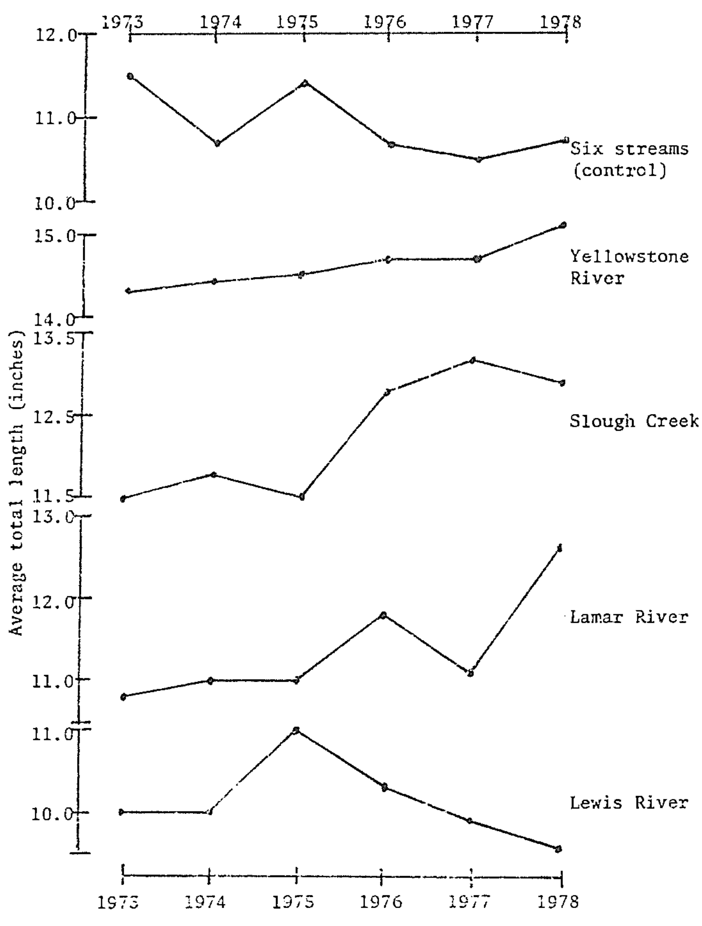


Figure 4.--Average length of trout landed from four Catch-and-Release streams and six similar streams (the control), 1973-78.

A closer look at some of these size relationships is warranted because the effect of C&R on size may be its most notable biological result. Contrasting brown and brook trout on the Lewis River is also informative because of the change in the frequency of the two species in the catch (fig. 5). Currently, brown trout are estimated to make up over 80% of the actual population. The decline of this species in the catch and in average size is interpreted as the superior ability of larger brown trout to avoid capture (or recapture). In this ecosystem, the highly catchable brook trout then takes on an exorbitant share of the angling pressure. The decline in their average size may be also due to the ability of larger individuals to avoid capture. Alternately, because of their small population, increased hooking mortality because of repeated recaptures may have been a factor.

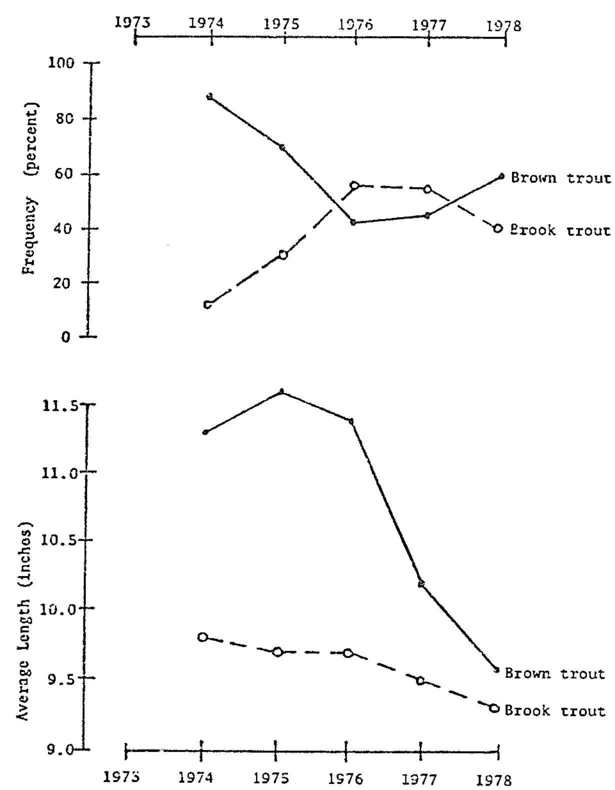


Figure 5.--The change in species composition and average length of brown and brook trout in the Lewis River Catch-and-Release section.

The average sizes of trout from Slough Creek may be representative of the effect of C&R on cutthroat, rainbow and hybrid trout (fig. 6). Contrasting the length frequency of the catchable population in 1968, which is reflecting a five fish creel limit, and a composite of data from the fifth and sixth years of C&R indicates major changes in the age-size structure of the population. These results show a precipitous decline in the number of small trout in the catch and presumably in the population and a corresponding increase in larger fish, including the reappearance of trout over 18 and 20 inches in the catchable population. Similar results were observed in the cutthroat trout populations from the Lamar and Yellowstone Rivers.

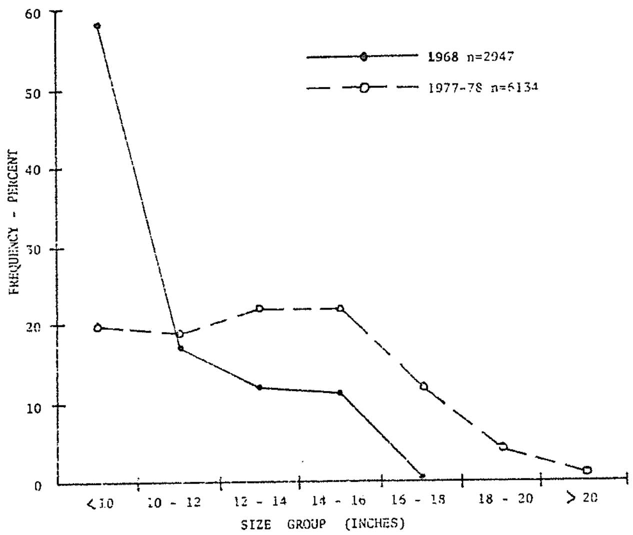


Figure 6.--Length distribution of cutthroat trout landed from Slough Creek under a 5 fish creel limit (1968) and following 5-6 years of Catch-and-Release fishing (1977-78).

It has been said that only new waters and new fish populations can add to the absolute number of fisheries available to man. Fisheries technology, on the other hand, can only change the form of what is already there. With the amount of water available for fishery purposes either already declining or which will almost surely begin to decline in the near future, technological advances may offer the only new, bright opportunities.

Most of us already think we know what fishermen prefer but a review may be in order. In a study of 6,000 Yellowstone Park anglers from all 50 states and all Canadian Provinces, we observed that fishermen like to catch many fish of large size. In the relationship of angler satisfaction to landing rates (fig. 7), note that satisfaction increases dramatically with the first few fish landed, levels off after the third fish, and levels further after a catch of 6-8 fish.

In the relationship of angler satisfaction to fish size (fig. 8), note that satisfaction is also a function of size. There is a minimum acceptable size (about 7 inches), and it also appears that Yellowstone fish do not grow large enough to satisfy all fishermen.

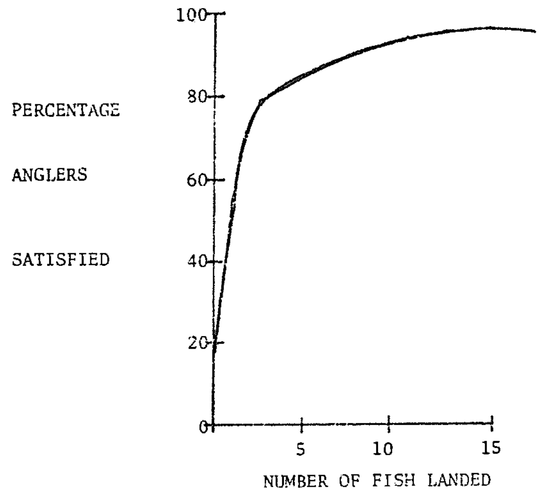


Figure 7.--The relationship between satisfied anglers (N = 6,000) and the number of fish landed, Yellowstone National Park, 1977.

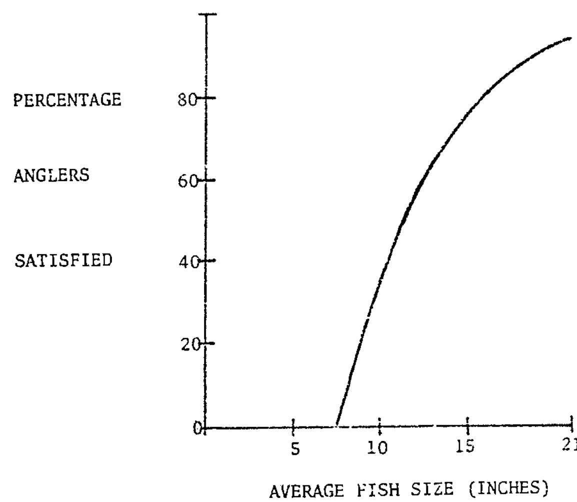


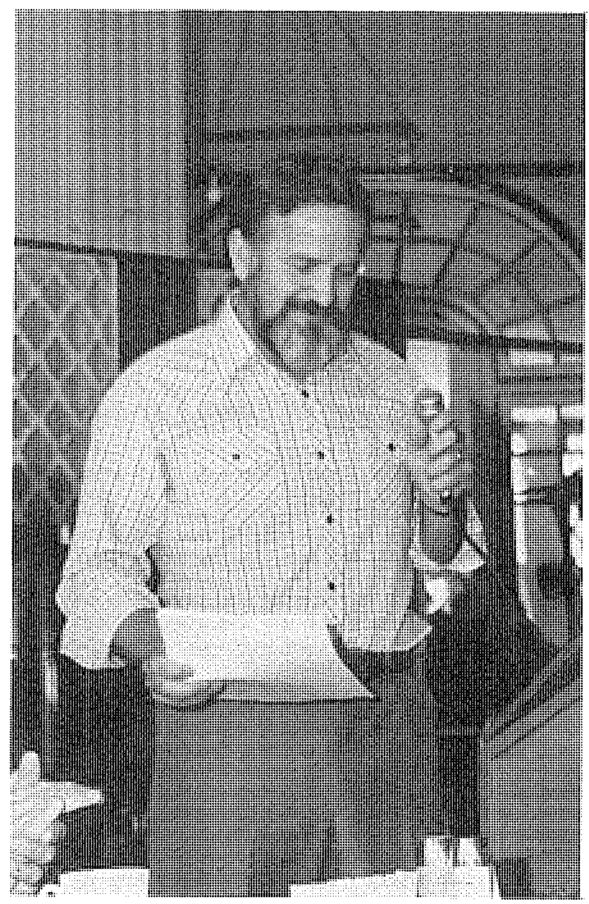
Figure 8.--The relationship between satisfied anglers (N = 6,000) and the average size of fish landed, Yellowstone National Park, 1977.

Examining Yellowstone's C&R streams with these two relationships in mind provides a measure of the relative value of C&R, from a sport-fishery standpoint. When cutthroat trout fisheries are considered, and perhaps rainbow and cutthroat x rainbow hybrid trout fisheries as well, the conclusion is reached that a higher value was obtained. The average number of trout caught per trip increased by an average of about 40%. Perhaps more important, instead of 33% of the fishermen catching one or more trout, as happened on the Yellowstone River in 1967, the percentage is now over 85%. From the standpoint of trout sizes, stockpiling older and larger trout in the population to create more satisfying angling (and perhaps a higher biotic potential as well) seems to be highly promising technology.

From the results of only one stream, the effects of a C&R regulation on brown and brook trout is not encouraging. While a significant improvement was noted in the number of trout caught, the increase was attributed to an abnormally high frequency of brook trout in the catch as a result of their increased vulnerability. Brown trout, however, became less vulnerable to capture. The average size of both species significantly declined.

A license-selling agency may take a particularly dim view of 50% declines in the number of anglers on a given water but that would be a narrow view. As we have seen, Yellowstone Park did not lose any anglers. In fact, the total number afield increased dramatically. The advent of a significant number of C&R waters in 1973 merely served to create a greater diversity of opportunity by redistributing fishermen in the Park.

Following the short period of C&R in Yellowstone, much remains to be learned. While some effects can be predicted in advance, others cannot. Each species appears to react in a different manner. It is obvious that what works for cutthroat trout does not necessarily work for brown or brook trout. The changes observed on lakes did not follow with streams. Indeed, the fish populations in each stream reacted somewhat differently. It is also clear that six years is too short a period to expect to see all that might happen. Each of the C&R fisheries continues to be in a dynamic state that may not approach a state of equilibrium for some years, if ever.



YELLOWSTONE LAKE - A LESSON IN FISHERY MANAGEMENT[1]

Robert E. Gresswell[2]

Abstract.--It has only been a decade since trout harvest and the removal of trout eggs from spawning tributaries combined to produce a substantial decline in the Yellowstone Lake fishery. During the 1950's and 1960's the management of Yellowstone Lake was based on the concept of maximum sustained yield (MSY), but shortcomings of this scheme became evident in the lake during the 1960's. Since then, more restrictive regulations which were implemented in an effort to enhance the cutthroat population have been only partially successful. Yellowstone Lake presently affords an opportunity to experiment with minimum harvest, high stock-density philosophies, such as catch-and-release angling, which may provide the only suitable answer for maintaining the cutthroat trout population at a level which is in harmony with the entire ecosystem.

Yellowstone Lake is a highly oligotrophic, subalpine lake with an average depth of 139 ft and a surface area of 87,450 a (Benson 1961). The native fishes of the drainage were the Yellowstone cutthroat trout (Salmo clarki bouvieri) and the longnose dace (Rhinichthys cataractae). Additionally two exotic species, redside shiner (Richardsonius balteatus) and the longnose sucker (Catostomus catostomus), are now abundant in the lake. A third exotic, the lake chub (Couesius plumbeus), has been collected sporadically since the 1950's. Although Yellowstone Lake may have the largest inland population of cutthroat trout in the world, it has only been a decade since a substantial decline in the fishery occurred.

Recent research indicates that two principal factors, hatchery operations and trout harvest, combined to drastically alter the cutthroat population. From 1899-1956, over 818 million trout eggs were removed from spawners entering Yellowstone Lake tributaries. A number of the larger tributaries to the lake were totally blocked annually. Although many of the resulting fry were later returned to the lake, genetic mixing of at least 140 reproductive entities undoubtedly led to extirpation of smaller discrete spawning populations. In some streams, reduced natural spawner escapement coupled with high angler harvest resulted in the virtual collapse of spawning runs (fig. 1).

The harvest of trout from Yellowstone Lake also contributed to the decline. By 1920, over 2 million trout had been harvested. Because of reports of substantial decreases in angler success, the daily creel limit was reduced to 20 in that year. Commercial fishing operations, which provided fresh trout for hotel guests, were also discontinued. By 1954, the cumulative harvest had reached 7 million trout which may be unprecedented for inland sports fisheries.

In 1948, the U.S. Fish and Wildlife Service began the first detailed studies of the trout population in the lake. For the next 13 years the research team attempted to determine the number and sizes of trout which could be annually harvested from the lake without deleterious effects. The results of these studies became the basis

[1]Paper presented at Wild Trout II Symposium, Yellowstone National Park, Wyoming, September 24-25, 1979.

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of fishery management for the lake in the next two decades (Laakso and Cope 1956, Ball and Cope 1961, Benson 1961, Benson and Bulkley 1963, Bulkley 1961, and Bulkley and Benson 1962).

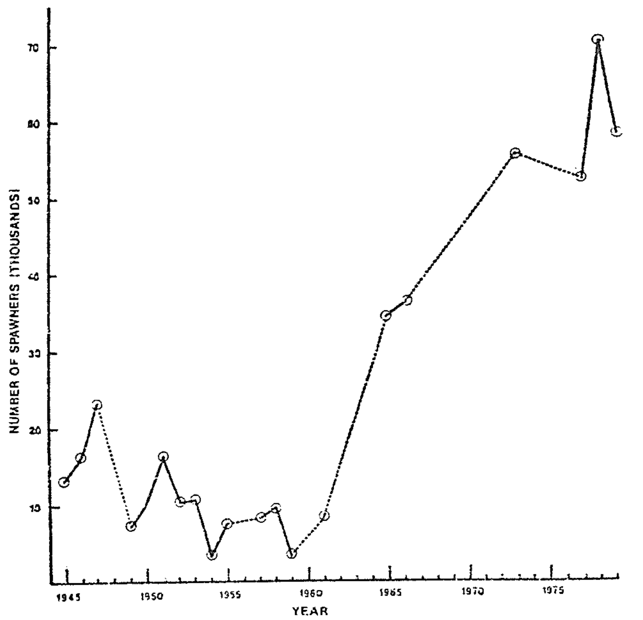

Figure 1.--Estimates of the number of spawning cutthroat trout ascending Clear Creek, Yellowstone Lake, 1945-1979.

During this period the management of the cutthroat population reflected the philosophy of maximum sustained yield (MSY) (Benson and Bulkley 1963). During the 1940's and 1950's, MSY had become widely accepted in both theory and practice by fishery biologists throughout the world (Larkin 1977). This management philosophy is based on the concept that all fish populations annually produce a harvestable surplus, and if this number of fish is removed each year, the fishery can be sustained indefinitely.

Despite widespread acceptance of MSY, fishery workers have begun to realize that this concept is often unattainable or unacceptable, and broader more realistic objectives are necessary (Ricker 1963, Roedel 1975, Larkin 1977, Sissenwine 1978). Biological shortcomings of the MSY philosophy have attracted increased attention and are well documented. Random fluctuations in the environment often aggrevate the rather delicate balance of recruitment and harvest (Ricker 1963, Beddington and May 1977, Sissenwine 1978). This management scheme also leads to reduction of genetic variability and the virtual elimination of some substocks (Larkin 1977). Another inherent problem of MSY is the decreasing predictability of catch when effort increases, especially when overexploitation causes the population to remain below MSY levels (Beddington and May 1977). Perhaps the greatest shortcoming of all is the lack of reliable feedback which would allow determination of yield prior to the beginning of the annual fishing season (Ricker 1973, Larkin 1977).

Given the distribution of fishing pressure during their studies, Benson and Bulkley (1963) estimated that the annual MSY for Yellowstone Lake was 325,000 trout with a range of 290,000 - 340,000. Catch statistics indicate that the removal of trout exceeded the greatest MSY for two years (1958-59), the average MSY for four years (1957-60), and the minimum estimate for seven years (1956-62). The effects of this overharvest were immediate. From 1963-68, the catch rate declined rapidly to a low of 0.5 trout/hr, and by 1968, harvest was lower than it had been in 20 years.

During the years of greatest harvest (1956-62), signs of overexploitation were apparent (Benson and Bulkley 1963). Spawning runs, which were monitored in six tributaries, displayed a steady decrease. At Clear Creek, for example, spawner counts dropped from an average of approximately 16,000 from 1945-48 to an annual mean of 7,000 spawners from 1956-61; only 3,353 spawners were counted in 1954 (Benson and Bulkley 1963) (fig. 1).

Perhaps the most interesting finding during this period was the inability to predict population density from catch per unit effort estimates. The failure of catch/hr to decline with decreases in stock density and increases in total effort may be indicative of depensatory mortality (fig. 2). According to Larkin (1977) this phenomenon can result from intense fishing effort on a population at low density. Sissenwine (1978) presented a hypothetical example of schooling fish where catch rate remains relatively independent of stock density because of man's ability to locate and harvest schools of adequate size. A similar situation may have existed in Yellowstone Lake when intense angling pressure was concentrated on cutthroat trout as they gathered in the vicinity of spawning streams. Benson and Bulkley (1963) reported that catch/hr was primarily influenced by spawning concentration, water levels and fishing methods.

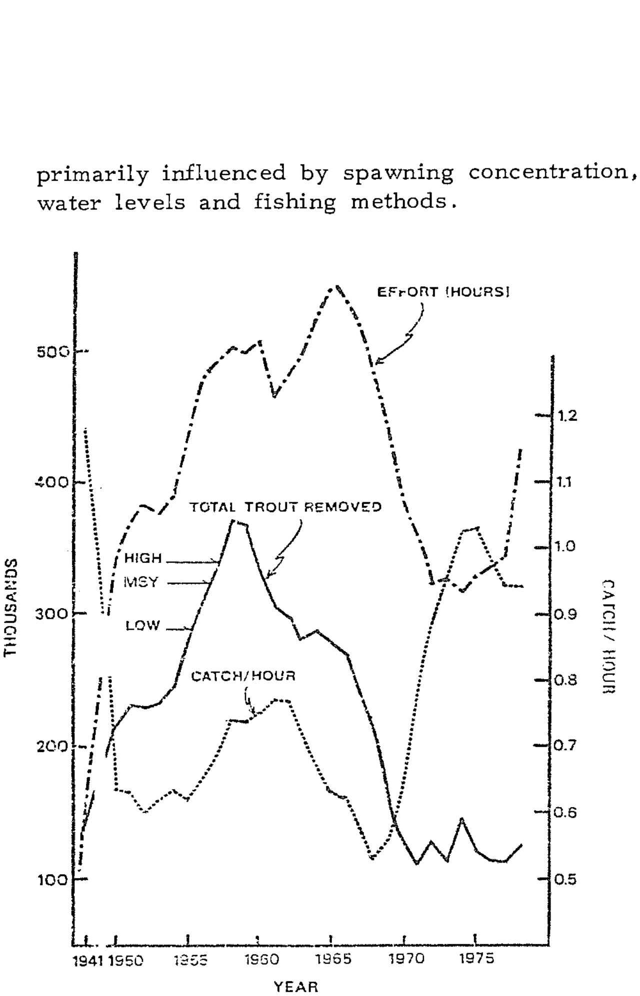

Figure 2.--Estimates of angler effort, catch rates, and total removal (includes estimates of hooking mortality after 1962) for the cutthroat trout fishery, Yellowstone Lake, 1941 and 1950-1978.

In 1962, the fishery management division of the U.S. Fish and Wildlife Service became responsible for monitoring of the Yellowstone Lake fishery. At that time, a fishing-for-fun program was initiated, which allowed the return of captured fish to the lake; prior to this change all captured fish were harvested. This regulation actually increased exploitation by increasing the length of time spent fishing and thereby increasing the numbers of anglers which captured their limit. Because needed bait restrictions were not implemented, hooking mortality also added to the total mortality for the first time. Despite a more restrictive three fish limit, the fishery continued to show the effects of overexploitation.

To halt the continuing decline of the fishery, a series of increasingly restrictive regulations were implemented. Bait became illegal (1969); a 14-inch minimum size limit was imposed (1970); and in 1973, Fishing Bridge was closed to angling and the creel limit was reduced to two. By 1974, annual harvest had stabilized at slightly over 100,000 (down from approximately 370,000 in 1958 and 1959) and catch rate had increased to 1.02 trout/hr (up from 0.5 in 1968) (fig. 2).

Despite signs of numerical resurgence, the 14-inch minimum size regulation hastened the decrease in the proportion of older and larger fish in the population. Although estimates utilizing the Walford line (Ricker 1975) suggest a maximum of eleven age groups prior to angler exploitation, fish age V+ and over were statistically absent from the catch by 1973. Spawning migrations were comprised almost exclusively of age III-IV+ trout. This result was viewed with great apprehension because of recruitment instability due to the lack of a multiple age spawning stock.

In an effort to improve the population age structure and further reduce the annual harvest, a 13-inch maximum size limit was initiated on Yellowstone Lake in 1975. Since then, catch rates and harvests have remained relatively stable despite annual increases in total angler effort of approximately 15%. The proportion of older and larger fish have increased in both angler catch and in spawning streams (fig. 3). Spawner counts at Clear Creek ranged from 53,000 to over 70,000 in the past decade, and the mean for four seasons has been 59,000 (fig. 1). Although these results are viewed optimistically, continued increases in effort suggest that harvest levels may again rise.

As dissatisfaction with the MSY concept grows, the search for a suitable alternative has become imperative. The concept of optimum sustainable yield (OSY) has received a great deal of attention (Roedel 1975, Larkin 1977). Although Roedel (1975) has provided a very broad definition of OSY, it is extremely difficult to determine its exact meaning. Since this term can be used to support extremely different management schemes, depending on the species and waters concerned, it must be regarded only as a general philosophical approach.

In recreational fisheries there has been an increasing emphasis on the quality of the experience rather than maximizing harvest. Fisheries yield within a Natural Area of the National Park System may include benefits which are not even associated with angling. The opportunity for scientific research on aquatic ecosystems in natural and often pristine conditions, which is uncommon throughout the world, is itself a benefit to society. It has become apparent that several Park waters are heavily utilized by visitors simply to observe fishes. Numerous wildlife species are dependent on a strong, healthy fish population for their own survival. The enhancement of other wildlife generates additional economic and personal yields.

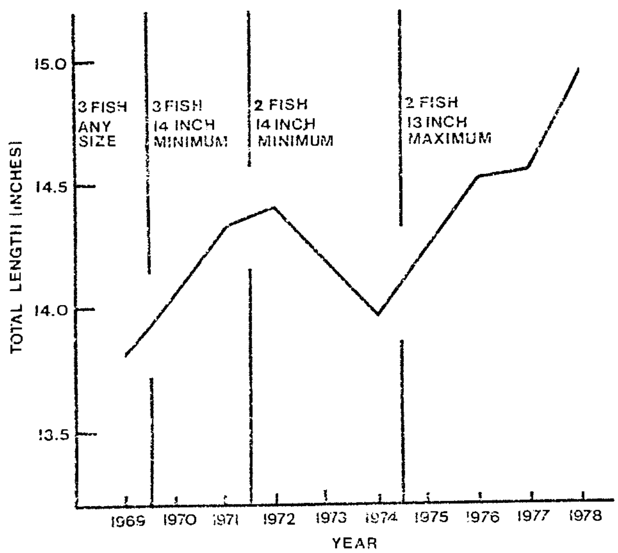

Figure 3.--Average size of cutthroat trout prespawners (judged as ready to spawn the following spring) captured in experimental gillnets, Yellowstone Lake, September, 1969-1978.

Despite the great size of Yellowstone Lake and its once seemingly inexhaust ble trout population, man has had, and continues to have,a significant impact on the ecosystem. Perhaps it was this incredible abundance and early high-quality angling which attracted anglers and maximized harvests during a period of liberal regulations. Silvert (1977) discusses this phenomenon in commercial fisheries and concludes that "the larger the initial population, the greater the danger of extinction!"

The location of Yellowstone Lake within a Natural Area of the National Park System affords an opportunity to experiment with minimum harvest, high stock-density management strategies, such as catch-and-release angling. Such management would sustain a quality angling experience while providing benefits for the non-angling public through opportunities to view large concentrations of native trout in their native habitat, and perhaps foster a better understanding of the function of aquatic ecosystems. Catch-and-release restrictions may provide the only suitable answer for maintaining the cutthroat trout population at a level which is in harmony with the delicate balance of the entire ecosystem while providing the opportunity for high-quality angling.

LITERATURE CITED

Ball, O.P. and O.B. Cope. 1961. Mortality studies on cutthroat trout in Yellowstone Lake. U.S. Fish and Wildlife Service, Res. Rpt. 55: 62 p.

Beddington, J.R. and R.M. May. 1977. Harvesting natural populations in a randomly fluctuating environment. Science 197: 463-463.

Benson, N.G. 1961. Limnology of Yellowstone Lake in relation to the cutthroat trout. U.S. Fish and Wildlife Serivce, Res. Rpt. 56: 33 p.

________ and R.V. Bulkley. 1963. Equilibrium yield and management of cutthroat trout in Yellowstone Lake. U.S. Fish and Wildlife Service, Res. Rpt. 62: 44 p.

Bulkley, R.V. 1961 Fluctuations in age composition and growth rate of cutthroat trout in Yellowstone Lake. U.S. Fish and Wildlife Service, Res. Rpt. 54: 31 p.

________ and N.G. Benson. 1962. Predicting year-class abundance of Yellowstone Lake cutthroat trout. U.S. Fish and Wildlife Service, Res. Rpt. No. 59: 21 p.

Laakso, M. and O.B. Cope. 1956. Age determination in Yellowstone cutthroat trout by the scale method. Journal of Wildlife Mgmt., Vol. 20, No. 2: 138-153.

Larkin, P.A. 1977. An epitaph for the concept of maximum sustained yield. Trans. Am. Fish. Soc. 106 (1): 1-11.

Ricker, W.E. 1963. Big effects from small causes: two examples from fish population dynamics. J. Fish. Res. Bd. Canada. 20 (2): 257-264.

__________. 1973. Two mechanisms that make it impossible to maintain peak-period yields from stocks of Pacific salmon and other fishes. J. Fis. Res. Board Can. 30 (9): 1275-1286.

__________. 1975. Computation and interpretation of biological statistics of fish populations. Fish. Res. Bd. of Canada, Bull. 191: 382 p.

Roedel, P.M. 1975. A summary and critique of the symposium on optimum sustainable yield. Pages 79-89. In: Optimum sustainable yield as a concept in fisheries management. P.M. Roedel (Ed.). Special publication No. 9. American Fisheries Soc., Bethesda, MD. 89 p.

Silvert, W. 1977. The economics of overfishing. Trans. Am. Fish. Soc. 106 (2): 121-130.

Sissenwine, M.P. 1978. Is MSY an adequate foundation for optimum yield. Fisheries. 3 (6): 22-24, 37-42.

OTHER USES OF THE AQUATIC SYSTEMS[1]

Daryl E. Jennings[2]

Abstract.--Yellowstone Park is used by many people for many purposes. Some areas are closed to fishing to accommodate other uses. In one area, angling pressure became too great and the resulting closure allows for far more people to enjoy a far more diverse experience than angling alone would provide.

Yellowstone National Park is for the benefit and enjoyment of the people--all of the people. We speak in terms of various uses, some of which are fishing, camping, geyser gazing, boating, etc. Sometimes one type of human use will interfere with another type, and hopefully the type of use that wins, or is allowed, is the one which is less damaging to the environment or the natural system. An example of conflicting interests, or use interference in the Park, was Hayden Valley, a prime wildlife viewing area. Prior to 1965, fishing was allowed in Hayden Valley and had reached levels which resulted in the reduction of wildlife such as bison, moose and elk near the River, and the reduction of waterfowl, eagles and ospreys on the River. The presence of fishermen on the River hampered wildlife viewing which was determined to be of a higher value - so fishing was closed in 1965. Since then the animals have returned and the valley is one of the best wildlife viewing areas in the Park.

It turns out that the Hayden Valley closure has enhanced the quality of fishing in adjacent areas. Hayden Valley has become a refuge where fish are totally protected from human disturbance.

An area where the same sort of thing has occurred and human use is well documented with much written material, facts and figures is Fishing Bridge.

The original bridge was built diagonally across the Yellowstone Lake outlet in 1902. It was elevated in the center to allow boat passage, and was officially named "Fishing Bridge" in 1914. A new bridge was built in 1919 which spanned the river perpendicular to its flow. The new bridge acquired the name of its predecessor. In 1937, the bridge was modified in that walkways were added for the convenience of fishermen and pedestrians. The bridge today is essentially as it was in 1937.

Prior to 1973, sport fishing was a major human activity in the area. Boating was allowed in the area through 1966 with a marina located just downstream from the bridge.

The history of fishing regulations in the Fishing Bridge area, and Yellowstone Lake in general, demonstrates the common pattern of increased restrictions with increased human use. The lake and Fishing Bridge area were under the same set of regulations until recently.

In the 1880's, fishing regulations allowed 20 fish per trip to be harvested by hook and line methods. In 1916, regulations limited the creel to 20 fish per day, with an eight inch minimum size. In 1921, the daily limit was reduced to ten fish per person. In 1949, the daily limit was again reduced, to five fish per person. In 1953, the regulations allowed five fish per day, but not more than ten pounds plus one fish could be harvested, with a 6-inch minimum size.

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[1]Paper presented at the Wild Trout II Symposium, Yellowstone National Park, Wyoming, September 24-25, 1979.

[2]Fishery Management Biologist; Yellowstone National Park and U.S. Fish and Wildlife Service cooperating.

Fishing Bridge was very convenient and made possible very intense fishing pressure in a very small area. In the late 60's, it was determined that the intensity of fishing pressure was unbearable. In 1967, the Fishing Bridge Marina was removed and boating in the area was prohibited. Finally in 1973 fishing in the area was totally prohibited.

Regulations on Yellowstone Lake over time have shown the same pattern of more and more restrictions.

Through the years many stories have been told and articles written about the fish and fishing in Yellowstone Park. One of the earliest concerning Yellowstone Lake clearly demonstrates the tendency for some authors to exaggerate slightly. L. Freeman in an article in Frontier Index in 1867 wrote of Yellowstone Lake "... thick with salmon trout of from five to forty pounds weight..." The following year he again wrote of Yellowstone Lake, "It was filled with fish half as large as a man, some of which have a mouth and horns and skin like a catfish and legs like a lizard." Other articles tended to be more serious. From the notes of the 1870 Washburn scientific expedition, we read, "The fishing, which had been good all the way up the river, proved remarkably so in the lake. Trout, from 2 to 4 pounds, were to be had for the taking." As early as 1874, concern was expressed in outdoor magazines about the health of the fish in Yellowstone Lake and the Fishing Bridge area. Fishermen were worried that the fish were skinny, did not get enough to eat and were overpopulated, causing them to be full of parasitic worms. In 1897 F.B. King wrote in Overland Monthly, concerning Yellowstone Lake outlet "... we anchored our boat in the current, and commenced catching fish on our flies as fast as we could haul them out. We caught two and three at a time, and they all weighed about a pound. In an hour and a half we caught twenty-nine fish that weighed a little over thirty pounds. There were so many fish that there was no great pleasure in catching them; it was all too easy..." In 1919, we find in the annual Superintendent's report for Yellowstone National Park that all of this great fishing had not gone on without a detrimental impact on the fish population. That report states that "... an encouraging feature of the season was the very large proportion of young spawning fish appearing in the various streams, apparently the result of plants made in the past few years, and indicating a return of fish in their former abundance before the depredations of the pelicans, gulls, etc., had made inroads on the stock in Yellowstone Lake." Although that 1919 report blames pelicans and gulls for reduced numbers of fish, it was certainly the activities of man which caused the problems. In hatchery operations for example, in 1915 about 5 million eggs were taken from the trout of Yellowstone Lake, about 7 million eggs were taken in 1916. Anglers were harvesting large numbers of fish as indicated by the popular articles and liberal fishing regulations. The activities of pelicans and gulls cannot be blamed since they had been present in the area for thousands of years and were undoubtedly in "balance" with the aquatic environment.

The time between the 1870's and 1920's must have been what one might call the hayday of fishing in the Fishing Bridge area, with a peak probably in the mid-teens. Sport fishing may never return to those levels. The quality of sport fishing since then has steadily gone downhill with increased angling pressures. In 1964, almost 49,000 anglers used the Fishing Bridge area and on the average it took 7 hours and 40 minutes of angling effort to catch a fish.

In 1973, Fishing Bridge was closed to fishing to protect the spawning runs, and since that time visitors to the Park have been using Fishing Bridge for observation of an aquatic system operating naturally. In May or June visitors can watch as some of the ice which had covered Yellowstone Lake for the previous 5 months is wind blown into the outlet area and passes under Fishing Bridge, cracking, scraping and grinding as it goes. Later, visitors can observe a very large concentration of adult native cutthroat trout in full spawning coloration. The process of spawning can be seen as males defend their right to a selected mate, females defend their redd sites and mating takes palce. Each female deposits in excess of 1000 eggs and the bottom gravel is essentially covered with redds. Many millions of fish hatch from eggs deposited in gravel of the Fishing Bridge area.

The adult fish spawning in the area come from two separate and quite different populations of a single subspecies of cutthroat trout. The lake population had become adapted to life in Yellowstone Lake, with its cold clear water and 5-month ice cover. Sexually mature adults move into the Fishing Bridge area in a downstream spawning migration and their offspring move upstream into the lake. The river population had become adapted to life in the Yellowstone River, deep and cold, meandering through wide valleys and rushing through steep canyons and over waterfalls. Sexually mature adults move into the same spawning area in an upstream spawning migration and their offspring move downstream and remain in the River.

The introduced longnose sucker also uses the area for spawning. Large numbers of suckers can be seen in the area a few weeks after the trout have begun to spawn. Spawning activities can be observed for about 1½ months, from early June through mid July.

All of this fish spawning activity, and its resultant production of millions of fry, attracts numerous fish eating birds. Pelicans congregate to feed on adult fish and steal the catch of mergansers. Kingfishers, ospreys and eagles occasionally can be seen feeding in the area. Trumpeter swans and various ducks use the area for feeding.

Certain mammals such as moose, muskrat, beaver and otter can be seen feeding in or moving through the area. Occasionally deer and elk are also seen in the area.

Later in the year, after spawning has ended, numerous cutthroat trout remain and can be seen from Fishing Bridge. The area can support an unusually large population of resident fish because it is a large lake outlet situation. Great amounts of plankton drift out of the Lake constantly and enter the river's food chain. These drifting plants and animals, originating in and adapted to life in Yellowstone Lake, have been sampled in large numbers as far downstream as LeHardy's Rapids (5.7 km) and probably contribute to the river's nutrient budget as far downstream as Sulphur Caldron (10.8 km). The greatest effect of these displaced planktonic organisms is undoubtedly in the Fishing Bridge area.

Large numbers of caddisflies, stoneflies, true flies and mayflies occur in the area occasionally producing what fly fishermen call a "super hatch". This is when huge numbers of immature insects rise to the surface to shed their last nymphal skin to begin life as an adult winged insect. They remain at the surface of the water for a short time, then fly to nearby vegetation. The trout in the area take advantage of this short period of hesitation at the water's surface and feed furiously.

During the winter, planktonic organisms continue to drift out of the Lake in lesser quantities. Of course in colder water the metabolic rate of the trout is far lower, and subsequently the food requirement is much less also. The normal river resident aquatic insects continue to contribute, as a food source, to the fish population during the winter.

In the spring of the following year the whole cycle repeats itself.

The stories of Fishing Bridge and Hayden Valley and the actions of the National Park Service demonstrate that observation is a more important use than fishing in some areas, and in terms of the goals and perspectives of this and many other national parks.

You might think that human use of Fishing Bridge must be fairly slight considering the vast numbers of fishermen who use the Park. In 1978, the level of human use of the Fishing Bridge area was determined. The bridge was used to observe the aquatic system from May through October. An estimated 134,710 visitors used the bridge for this purpose, spending a total of 24,303 man-hours. In August the number of visitors using Fishing Bridge exceeded the number of anglers Parkwide. The number of visitors using the bridge during the summer of 1978 exceeded the number of anglers using the top eleven waters in the Park (Yellowstone Lake, Yellowstone River, Madison River, Firehole River, Gibbon River, Gardner River, Lamar River, Lewis River, Slough Creek, Lewis Lake and Shoshone Lake). These eleven waters hosted almost 90% of the total Parkwide anglers.

Other areas of the Park used by visitors specifically to observe fish or the aquatic habitat include LeHardy's Rapids and the Gardner River.

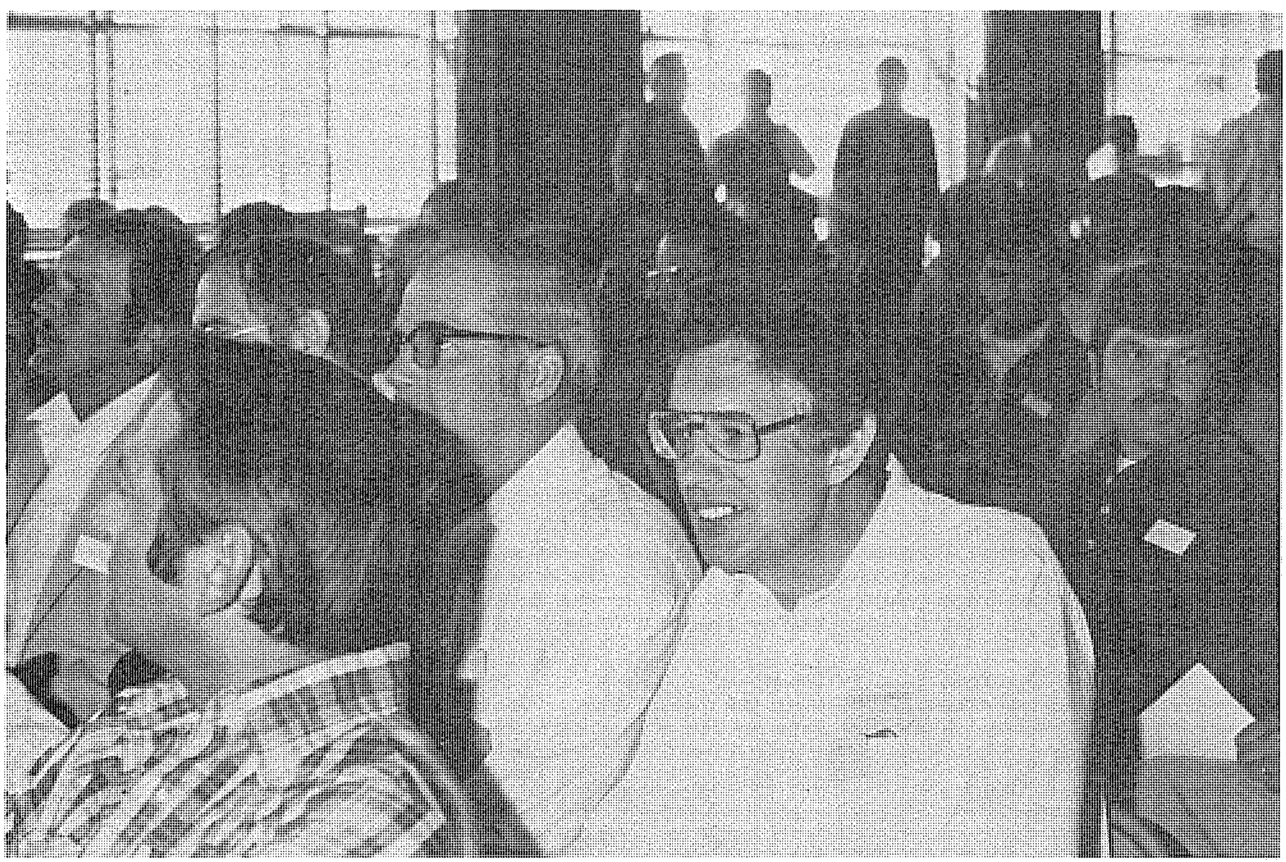
LeHardy's Rapids is a point on the Yellowstone River about 5.7 km north of Fishing Bridge. During the late spring and early summer, native cutthroat trout ascending the Yellowstone River in their upstream spawning migration, congregate adjacent to the west bank. They find an avenue of ascent by jumping at a point very near the bank. It is this massive congregation of fish and their jumping that visitors are able to see and enjoy. Fishing is not permitted in the immediate vicinity of the rapids.

There is a point on the Gardner River about 2 km south of the North Entrance station where, in the fall, non-native brown trout can be seen jumping to surmount rapid water in their spawning migration.

We have seen that the history of fishing regulations, here as well as all over the country, proceed from liberal to restrictive, from harvest to catch-and-release and, here in Yellowstone Park, in certain areas to no fishing at all. This final regulation does far more than merely remove fishermen. It allows a heavy use of a diverse aquatic ecosystem by a wide variety of people. Folks see and enjoy these aquatic systems operating as an integral part of the total system.

In terms of a national attitude toward fishing, these areas tend to increase popular interest in angling. Park information urging care in handling fish, regulations such as catch-and-release, and total protection during spawning makes angling tolerable to those who consider the harvest of fish to be out of place in a national park.

Restrictive regulations, effective protection of spawning runs and careful, concerned and informed anglers are the key to the future of the great sport of angling, in a great area.



THOUGHTS IN CLOSING[1]

Robert L. Herbst[2]

It's a privilege to find myself for the last two days in the company of those knowledgeable outdoor people who not only savor the experience but value its highest qualities.

I am here this evening to report on the Nation's stewardship with regard to trout fishing and the complex resource base that supports it. But I'm also here as an avid angler, and I am as eager as any of you to keep our efforts on that track.

Occasionally tonight I will say "I" but let me stress that it is "we"--and it must be "we"--and I will conclude with stressing that message. Let me begin tonight by describing the approaches that we are undergoing.

At Interior we view the fisheries task from both a specialist and a generalist point of view. Our eventual goal is synergism--the healthy, productive synergism--the feeding of the processes of one resource to another producing something excellent, something that is more than the sum of its parts.

The pieces we're working with are many, and I will deal with some of them specifically before I move on to the way that we see them all fitting together, and to the goal we expect to reach.

I will start with individual projects within the Fish and Wildlife Service, then I'll move on to the National Park Service fisheries programs, I'll swing in wide to take in the Great Lakes Fishery Commission's projects, and then I'll touch down with a preview of how I see this institutionalized into a National Fisheries Recognition System.

In this way I intend to give focus and direction to what is often, I believe, the least tended of our national resources in the same way that we already have given direction to our national forests, our national parks, our national wildlife refuges, and our national historic sites.

One luxury we can no longer afford is that of flailing away at every new movement that catches our eye. Like the tropical flies that seek to move away from the attention of the lightning tongue of the lizard--and remain motionless and uneaten--some of the pieces of our fisheries puzzle escape corrective action.

Now I know it's a soul-satisfying exercise to denounce and call down the wrath of the gods on every highly visible deviation from the fisheries gospel. But the quiet little errors need correction too. And the detection of these errors is best accomplished when the effort is to survey the entire picture--the whole picture--to seek a holistic program, one that misses nothing of what is already in place, and one that tends to show what is lacking and then do something positive about it.

The tasks that are necessary in order to produce a healthy, functioning whole fisheries policy have tended to literally "fall out" when we take such a look. Noisy outrage, and just-as-noisy enthusiasm, must be toned down and the programs and the policies that spawned them must be looked at again, in true relationship to the overall picture, the overall natural resources and the overall variety of uses.

This is the kind of look that I have been gathering the pieces for--and I am pleased to report that most of these pieces are either in place or they will be inserted. The picture is a movie, and in some cases it turns out that the individual piece, when seen apart from the rest, is entirely different when we see it with the entire picture.

One thing I'm sure we can agree upon tonight is that a high grade trout stream is not "fat city." A quality angling experience is one where you and I, as fishermen, pit our wits and our skills and our luck against the best representatives of a lean, a healthy, and a sinuous system. The fish we go after is part, parcel, and product of that entire system.

And that is the way we are going about managing our fisheries. Our target is a system

[1]Paper presented at the Wild Trout II Symposium, Yellowstone National Park, Wyoming, September 25, 1979.

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that consists of fish and consists of fish habitat! I am delighted to report that we are making excellent progress in that direction.

We have seized the central trouble of what we call the "troubled times" of this year--the low energy/high cost situation--and we are making it work for us. We are riding the direction that it is nudging us toward--trimming away our excesses, cutting the programs that have catered to fat in our own human needs; and we are working toward a lean, muscular, but a very exciting brand of management that will be a fitting match for the entire system that we are managing.

That approach is not so much new as it is newly and consciously tailored to the times of today and tomorrow. I am particularly pleased with the way we are beginning to carry out our laboratory and our hatchery research and carry it to the wilds. We've had, I believe, some heady results, particularly in our work on rainbow trout.

Let me give you one example. A rainbow trout study began 10 years ago, with development of a data base and methodology for choosing the best strains--best suited for particular experiences, best suited for particular conditions. The Fish Genetics Lab here in Wyoming eventually wound up with 18 strains of rainbow--12 from hatchery brood stocks and 6 from wild sources--all characterized and evaluated for growth, survival, reproduction, catchability, and a variety of other traits.

The lab phase of that program showed significant differences between the strains, especially in the growth rate, the feed conversion and survival capabilities. We field tested, first in lab ponds and later in the wild, and the differences have been borne out.

That experiment has continued, with an eye to other traits that will spell out improvements in species and improvements in the sport.

Now that we are satisfied with some of our lab and lab pond data, we are moving out in a major way into field testing. Our biologists are going out into the wilds under a variety of environments, working closely with state biologists, to bring the fish and the habitat together in the highest quality and the most intense sporting conditions available.

As part of the process of trimming fat and tightening network conditions, we are phasing out the genetics work at the Beulah Lab, and we are picking it up at the National Fisheries Center in Leetown, West Virginia, and elsewhere in our system.

Beyond the Lab and the fish are people, and I know that many people--and especially managers--chafe at the words "environmental education," but I am convinced of the necessity to inform the public and to enlist their support if our agency missions are to succeed. But beyond being informed, the public must be involved in both the planning and in the decision-making process. They are no longer content to be handed decisions cocked up by government on a silver platter, nor should they be. And so it strikes me that environmental education is the only honest, intelligent way of guaranteeing, in the long run, wise management practices not only of fisheries, but our entire natural resource spectrum. In that connection, we have institutionalized a communications system within the Fish and Wildlife and embarked upon the same type of system in the National Park Service.

In line with other efficiency moves, the news from the construction front is also heartening, I believe. New structures are being built across this Nation and old buildings are being retro-fitted. They are being retro-fitted to run, wherever possible, on direct or indirect solar power.

The National Fisheries Center in Leetown, West Virginia, is a miracle of response to the present energy conditions. This summer we dedicated that facility. It is the largest fish health lab in the world, with the finest fish scientists in the world. It is also the largest solar operating facility in the world. It is heated and cooled by sun power, and every scrap of waste heat in the entire operation is re-gathered and put to appropriate use.

We have made a preliminary energy audit of all of the facilities in the Fish and Wildlife system, and we know precisely how much energy we are using. We now are moving to the second phase which is to cut back on that energy consumption and eventually retro-fit in the most appropriate way to conserve energy.

In that same vein--better use of our limited dollars and people--we are putting together another system in the Fish and Wildlife Service. It is called "Important Resource Priorities"!

The development of goals and objectives is essential to any planning process whether you're running a business or whether you're running a government organization. The basis for goals and objectives is to define what is important to that organization. Our Fish and Wildlife Service has the ecosystems which are important to fish and wildlife. Their mission is to provide Federal leadership to protect, conserve, and enhance the fish and wildlife resources of this Nation. But given limited dollars and limited manpower, it becomes necessary to limit our activities every year to the most important aspects of that mission insofar as possible.

We have now defined the fish and wildlife resources of the entire Nation with problems in specific geographic areas in terms of relative concern. In a recent meeting of our field people and our Director, we selected over 150 resource problems. A final list of 70 was selected and will be used as the basis for budgeting and for the allocation of our manpower resources.

I am pleased to report to this audience, as an example, that the No. 1 resource priority of the Fish and Wildlife Service is steelhead trout, chinook and sockeye salmon in the Columbia River Basin. The national importance of that resource is immense--but the potential for its demise is also immense. And so those two factors (its high value and its high threat) led to the Service's decision to rank it as its No. 1 resource problem to address.

Again, in the interests of tightening our management and avoiding overlap and duplication, I instructed the Director of Fish and Wildlife and the Director of the National Park Service to convene an ad hoc group of senior fisheries management and research specialists. I asked them to review and evaluate the fishery policies and operations of the National Park Service, and to identify how they could both work together to fulfill their functional responsibilities in the management, the care, and the use of those resources.

As Gordy Watson has reported to you--and I might mention that you are the first group to receive this report--the recommendations are in, the National Park Service has commented on them, they will appear in the Federal Register probably next week. Following public input, the Director of the Park Service and I will make the necessary decisions and implement the changes that are desirable.

We must talk--we must listen--public participation is essential. Let me give you an example. Fishing in the Everglades National Park's Florida Bay has attracted national attention because of the decline of the fishery resource into a serious state of depletion. Sport fishing organizations, conservation groups, and the national press clamored for action. We took action. We undertook a biological and an economic review of the Everglades National Park fishery, defined the management options, costed them out, published the results, and held public hearings and workshops. The hearings and workshops were very well attended. We had lively debate and a clear expression of public opinion. Commercial interests want to continue fishing in the Park; however the overwhelming majority of people who expressed themselves believe that commercial fishing should be stopped, and that creel limits must be placed on recreational anglers so that the fishery resource can recover and maintain itself.

The National Park Service agrees and I agree. That plan is now out for public comment, and we are hopeful of finalizing it and implementing the changes. From the comments so far, it is obvious that the public agrees with the recommendations that have been sent to the Register.

No look at the overall fisheries program in this Nation would be complete without reference to the Great Lakes. Here's the way that a large segment of concern is shaping up. We have recommended that a comprehensive Fish Management Plan be developed for the Great Lakes--one that would pull together the efforts of the various governmental agencies that deal with the enormous resource--a fisheries resource that is worth right now one billion dollars a year in sport and commercial fishing, and to say nothing of its intangible values and the fact that its values can be greatly increased. A meeting was held with representatives of eight states, two major Federal agencies, the Federal Government of Canada, and the Province of Ontario. That gathering accepted the Great Lakes Fishery Commission proposal--that a plan would be developed that will affect 37 units of government and set a capability and money for coordinating our management and our preservation efforts.

Moving from the Great Lakes to the Nation itself, I now come to the idea I have of establishing a National Fisheries Recognition System. But before we examine its merits, let's examine how it has worked in other areas. Through the farsighted efforts of conservationists--both professional and lay people--in the present and in the previous century, relatively large tracts of Federal lands have been set aside: national parks, forests, recreational areas, refuges, and wilderness areas.

Behind those efforts was a realization that the Nation had to recognize and conserve its land resources. Some of these areas, like the one you are in (Yellowstone), Grand Canyon and Yosemite, appeared remote and isolated from people and development. But it was recognized even then that these areas would face substantial development pressures in the future, and that unless they were protected before these pressures were mounted, their natural and their cultural values might be lost forever.

With regard to fisheries, it is the <u>only</u> resource that we have not addressed in a national way. The time is later than it is and was for land; but there still is much, due to management and protection that has gone on, that can be saved from extinction--providing we act in a wise and timely manner.

The fish resources of this country are held in public trust by the governmental agencies across our Nation. The public can be regarded as stockholders of the resource, since the fish belong to no one until they are legally caught. Many of these resources are scarce in relation to the demand, and there is an increased competition in terms of the demand for a share of that resource. Not all shares are equitable, and there is a tendency to deplete our fish stocks. Overfishing has occurred worldwide because of the relatively open access to the commonly held fish resources of this world. Only in recent years have we examined the record and begun to take significant steps to protect those fish stocks that bear the brunt of increased and intense competition.

With the stresses on our fishery--because of pollution, overfishing, habitat destruction, the invasion of the environment by new species, etc.--our traditional fisheries are diminishing in many places. The various Federal and State agencies that are jointly responsible for our national fisheries must recognize a responsibility to society at large for at least preserving representative, outstanding examples of the traditional fisheries for future generations. It is that responsibility to society at large that leads us to induce changes in the entire fish system of this country.

We must look beyond the State's lakes and its streams. We must look ahead to what we are leaving for tomorrow's society. Our management of today's fish resources must be balanced, and must be creative. It should concentrate on <u>making</u> the future, not reacting to it day by day, one day at a time!

The approach I will be proposing soon for State and public comment offers a new context for fish management--a System of National Fisheries Areas.

In 1978, I wrote a memorandum to the Director of Fish and Wildlife Service suggesting this new System, asking him to develop a concept of a System to take care of the great national resource still unrecognized and still lacking a cohesive national policy. I requested development of the concept--and before Jack Grieb and others go through the ceiling--one that would not affect State responsibilities and sovereignty.

With lightning speed, he was back with the concept. The recommendation--a System that could be established within existing legislative authority. It would have two goals--a natural and a cultural goal.

The natural goal will be to identify and conserve the integrity and the diversity of the nationally significant components of the Nation's fish resources and the environment in which they exist. Examples: the Iliamna watershed of Alaska in which 27% of that State's spawning for salmon takes place, and many others.

The cultural goal is to identify and conserve the fisheries of special recreational value for the long-term management and benefit of society. Examples: the Madison in Montana, the Au Sable in Michigan, and many others.

Using the Fish and Wildlife Act of 1956 as our primary authority, the System can be administratively created by the Secretary or Presidential Executive Order. It will be very similar to the National Landmarks Program of the National Park Service, and it will consist of the following:

1) The identification and publication of the National Areas,

2) The listing in a Registry,

3) The demarcation by a plaque,

4) Certification to the owner, and

5) Protection mechanisms that will involve restrictions, criteria, and guidelines in the use of permits, grants, and other processes which affect projects that, in turn, affect fisheries of national significance.

The recommendations for designation would be submitted by any governmental agency, by any state, or by any individual. The Federal Government will not gain possessory interest in the land or the fish resources involved.

And now I invite your attention to the one last consideration as we look at fishing opportunities and management. That consideration is the set of environmental and economic constraints under which we <u>all</u> operate today.

It isn't just oil that is the example of the end of a valued resource. The recent confrontation in the Northwest between commercial fishermen and the law is a strong indication that our fishery stocks, too, are and can be in trouble.

The vital difference is that oil is renewable only in the time frame of thousands of millennia--this means that, from the human point of view, oil is a non-renewable resource. Fish, on the other hand, <u>are</u> a renewable resource, providing we do our part in seeing that the fish are given the raw materials and the conditions necessary to their continued production.

The bottom line in resource management is to maintain the conditions that produce the products we want. Whether that product is redwood lumber, canned salmon, or a customer on the end of a line with a trout, the central question is the same: Can we preserve the set of circumstances that keeps delivering these desirables? Can we perpetuate the process whose pay-off points we are overcrowding?

Like slot machine junkies, we can shake the machine, we can kick it, and we can call it names. Or we can back off and consider the limitations of the machine and the demands that we are placing on it.

For those people who scream and rail at any authority that would come between them and their prized goal, the answer I suggest to you is relatively simple. You either preserve the goose, or you say goodbye forever to the eggs.

That boils down to putting the environmentalists and the economists in the same boat. They will be uncomfortable at first--and they should be, after all the naughty, nasty, snide things they have said about each other.

But the embarrassing fact is that they are partners--dependent on the same process, valuing much the same experiences. The fortunes of their seemingly divergent goals actually ride on the same resources and are driven by the same forces.

Nat Reed was the first to recognize this when he addressed you several years ago. Now he comes from an economically conservative background, and before this gathering he loudly deplored the failure of his fellow political conservatives to speak up on behalf of the environment.

"How can it be?" he asked, "that the protection of land, water and wildlife and the proper management of the Nation's natural resources is classified as a 'liberal issue?' Obviously," he said, "it is all mixed up! The protection of our land and our resources should be a conservative mandate."

I can't think of a more convincing spokesman for that point of view. He understands the natural system, the natural resources--the underpinnings of our economic system. He reported to you his wry amusement of one of the conservative candidates who sought his support for elective office. Nat said: "I pointed out to him rather rudely that he had a consistent environmental record. He had, in fact, voted against every piece of environmental legislation for the last eight years."

Nat Reed found that incomprehensible, as I do and you do. And I predict that the electorate--many of them that take the same shortsighted view of their paycheck as some of the corporate moguls take of their balance sheet--are very shortly going to see the long-term nonsense of putting the environmental and the economic concerns in different corners and treating them as mutual enemies, instead of simply as two manifestations of one phenomenon--our Daily Bread.

Many of us understand the Biblical reference to "daily bread." It covers all kinds of sustenance that were put here as part of the Earth--physical, mental, and spiritual--to satisfy the various needs, gnawings and thirsts that all kinds of people feel.

Along with that bounty goes a heavy responsibility, and every one of us has the opportunity to step forward and be counted. And you'll be counted whether you step forward or not.

Some of you may have read Dr. Lewis Thomas' prize-winning essays, "Lives of a Cell." He heads the Sloan-Kettering Cancer Institute, and he now has a new book which I hope you do read. It is equally thought-provoking. It is called The Medusa and the Snail.

In it, he looks at the Earth as a single organism with many parts--the most recent of which is humankind. He begins with the tongue-in-cheek suggestion that anyone that is looking for life on other planets must go equipped with "special instructions . . . for detecting the presence of committees. If there is life anywhere," he says, "you will find consortia, collaborating groups, working parties all over the place." Maybe even a larger Federal Register than we have!

He suggests further that "the Earth holds together--its tissues cohere. It has the look of a structure that really would make comprehensible sense if we only knew enough about it."

Then, instead of wringing his hands and accusing humanity of "doing in" this lovely, significant creature that is Earth, he remarks optimistically that we really have come a long way in a relatively short period that we have been on the scene.

"We are the newest, we are the youngest, and we are the brightest thing around," he says.

I like his thinking and I hope he is right. I will borrow one more sentence from him to keep our pride in balance as we seek to orchestrate the world. It is his comment on the human propensity for "swarming like bees" over the entire surface of the Earth, "making believe we are in charge."

That's the phrase that makes one pause and wonder--"making believe we are in charge." It nudges one toward humility. How much "in charge" are we really? How far can we continue to impact the natural resources--to stretch the natural systems--before they sag and seek new balances at far lower levels of "quality" than we will be satisfied with? And how much attention are we willing to pay the Giver of all these gifts--whether you recognize the giver as God or simply recognize and respect it as a system?

These are the questions that look over my shoulder as I read the reports and the recommendations of Task Forces. These are the imponderables that tug at my sleeve--reminding me of the need to reconcile the reports with the larger syetem that underlies them--reminding me, too, of our responsibility, as "the newest, the youngest, the brightest thing around"--making believe we are in charge.

None of us, individually, is in charge. We must do things together--cooperate. That's what I've enjoyed most about this conference--Government and other professional research, management and policy people are here with lay conservationists, young and old alike--and I am especially impressed by the number of younger people. We are talking and doing together, and that's as it should be, because we not only need help and guidance from our Maker, we need to work with each other instead of isolating ourselves on islands of independence worrying about each other's turf.

Perhaps I can illustrate this in conclusion with a short story.

FOOTPRINTS

One night a man had a dream; he dreamed he was walking along the banks of his favorite trout stream with the Lord.

Across the sky flashed scenes from his life. For each scene he noticed two sets of footprints in the sand--one belonging to him and the other belonging to the Lord.

When the last scene had flashed before him, he looked back at the footprints and he noticed that many times along the path there was only one set of footprints in the sand. And he noticed that this happened during the saddest and the lowest times in his life. This really bothered him and he questioned the Lord.

"Lord, you said that once I decided to follow you, you would walk with me all the way, but I notice that during my most troublesome times there was only one set of footprints. I don't understand why, when I needed you most, you deserted me."

The Lord replied, "My precious child, I love you, I would never leave you. During your times of trial and suffering, when you see only one set of footprints, it was then that I carried you."

I submit to you that during the dark moments and, in fact, during all the times, we must carry each other, work together for the common interest: trout, its habitat, and the larger picture of a quality environment for our generation and for those generations to follow. We are all in this life together and mankind will be perpetuated or will perish, depending on what we do together.

SPORT FISHING FOR THE NATIVE ARIZONA TROUT, SALMO APACHE MILLER IN CHRISTMAS TREE LAKE: A CASE STUDY

John N. Rinne, Fisheries Research Biologist

Ben Robertson, Fishery Management Biologist

Ron Major, Hatchery Biologist

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Abstract.--Population estimates of legal-sized fish (746 ± 116), their rate of exploitation (0.45), angler success (0.25 fish per angler hour), and reduction in the proportion (from 70 to ca. 15%) of legal-sized fish before and after fishing, indicate the native Arizona trout, Salmo apache Miller, in Christmas Tree Lake will not maintain a quality sport fishery under heavy fishing pressure.

INTRODUCTION

Christmas Tree Lake was constructed by the White Mountain Apache Tribe in 1966. Upon filling in spring 1967, native Arizona trout, Salmo apache Miller, from Ord, Firebox, and Deep creeks, Arizona, in addition to fry from Ord Creek being held at the State of Arizona's Sterling Springs Hatchery were stocked in the lake. Prior to impoundment the two confluent streams (fig. 1) were chemically renovated to remove non-native salmonids and suspected hybrids between rainbow trout, Salmo gairdneri Richardson, and the native trout. Cursory studies since establishment of the population in the lake have indicated the presence of brown trout, S. trutta Linnaeus, and possible Arizona X rainbow trout hybrids.

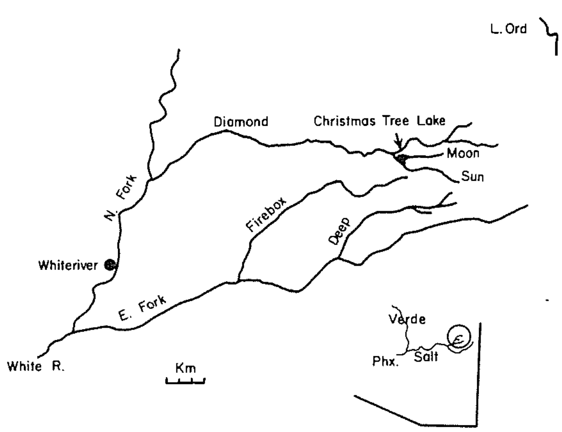

Figure 1.--Map indicating the location of Christmas Tree Lake, Fort Apache Indian Reservation.

Similar to management practices for all stream populations of native Arizona trout on the Fort Apache Indian Reservation, Christmas Tree Lake has been closed to sport fishing during most of its existence. Sport fishing was allowed only for 7 days in 1969, a month in 1970, and more recently, for a 9-day period in October 1978. Four hundred and fifty licenses were sold for the 1978 season. Angler catch was monitored and only fish greater than 355.6 mm (14 inches) were considered legal.

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In advance of this fishing on an essentially unexploited population of S. apache, experimental netting was conducted by the U. S. Fish & Wildlife Service, White Mountain Recreation Enterprises, and the U. S. Forest Service, Rocky Mountain Forest and Range Experiment Station in July 1978. The four main objectives were to: (1) estimate the population size of S. apache in the lake by Petersen tag-recapture methods, (2) determine the effects of fishing on the population, (3) determine the incidence of infectious pancreatic necrosis virus (IPNV) in the wild trout population, and (4) define genetic purity of the population. In addition to specimens collected in 1978, specimens from 1970, 1971 ,and 1976 were analyzed for taxonomic purity and specimens from 1975 for IPNV. Results of these analyses and of the sport fishing exercise in October 1978, along with their management implications, are presented in this report.

DESCRIPTION OF STUDY AREA

Christmas Tree Lake is a small impoundment in mixed conifer forest at 2,500 m elevation. At full pool the lake covers 16.7 surface hectares and is 13.7 m in maximum depth. It has a full-capacity volume of 100 hectare-meters. It is located at the confluence of Sun and Moon creeks (fig. 1), tributaries to the Diamond Creek system which flows into the North Fork of the White River.

Surface water temperatures reach 17 to 20° C in summer and the lake freezes in winter. Stratification occurs, and dissolved oxygen in July 1978 was 8 mg/l down to 3.0 m. Beds of aquatic vegetation occur in the littoral areas of the lake.

MATERIALS AND METHODS

During 6 days of sampling between 19 and 29 July 1978 most (106) S. apache were captured in trammel nets (91 X 2.5 m; 38 mm mesh, bar measure), and fewer by hoop nets (32) and angling (28). Trammel nets were run every hour to reduce mortality. Once fish were removed from nets, they were immediately weighed and measured then tagged with a sew-on fry tag through epaxial musculature immediately anterior of the dorsal fin. Specimens were held in a live box to confirm recovery prior to release into the lake. Kidney and spleen tissue were removed from netting mortalities for IPNV analysis. All mortalities were then preserved for later taxonomic study.

Kidney and spleen samples were homogenized and filtered according to the method of McDaniel (1975) and inoculated onto rainbow trout gonad (RTG-2) monolayer cell cultures. Inoculations were in replicate and incubated at 15° C for 14 days. If cytopathic effects were observed the suspect material was transferred at 10^{-3} dilution adsorbed with 1:100 polyvalent IPNV antiserum and incubated for an additional 14 days for confirmative diagnosis. Ovarian fluid and fecal material from samples taken in 1975 were assayed using these same methods.

Methods of taxonomic analyses were described by Rinne (1978b). Six morphometric and three meristic characters were employed in comparisons of samples of different taxa, and of S. apache collected in different years.

Anglers were surveyed during the 9-day fishing season. Creeled fish were weighed (lbs) and measured (inches TL). Measurements were later converted to metric units. Anglers were queried as to the number of "sub-legal" (<355 mm) fish returned to the lake and whether or not fish had tags.

Population estimates are based on the Petersen Method employing a single mark and release. The statistical procedures for the study are from Seber (1973:59-60).

Standing crops, condition (KTL), and rates of exploitation of large (>228.5 mm) and legal-sized (>355.6 mm) S. apache also were calculated.

RESULTS

Capture-Marking Operation

Similar percentages of legal-sized S. apache were captured by trammel netting and angling (72% and 64% respectively). By contrast, hoop nets caught fewer (ca. 40-50%) legal-sized and more less-than-legal-sized fish. The smallest specimens captured in hoop nets were 91 mm. By comparison, fish captured in trammel nets and by angling were never smaller than 228.5 mm (229 and 233.7 mm, respectively). Most tagged fishes (60%) were released near the dam or at the downstream end of the lake (fig. 1). Equal proportions (19%) were released in the Sun and Moon arms. This uniform release pattern combined with the 3-month interval between tagging and fishing permitted assumption of random distribution of tagged fish in the lake.

Harvest Data for the 9-Day Fishing Season

Only 301 of 450 anglers (67%) that purchased licenses actually fished. Each angler averaged nearly 6 hours of fishing for each legal Arizona trout (table 1).

Table 1.--Summary information for harvest of Arizona trout during a 9-day fishing season on Christmas Tree Lake, 1978.

Total anglers	301
Total man hours fished	1,908
Hours per angler	6.3
Legal checked	333
Illegal checked	38
Sub-legal released	62[a]
Calculated returned in the 1st 3 days	30
Total caught in 9 days	463
Fish per man hour	0.25

[a]Doesn't include 1st 3 days of fishing season

This ratio becomes 1 fish for every 4.5 hours if one considers the total fish caught (including legal- and less than legal-sized fish). Finally, if one estimates an additional 30 fish for the 3 days of no records, about one fish was angled per every 4 hours of fishing. Seven of every ten *S. apache* caught were legal-sized. This proportion is similar to the size distribution of fish captured by angling and trammel netting during the tagging operation. Forty-one of the 371 fish checked were tagged (table 2).

Table 2.--Summary of mark-recapture fishing and exploitation rates (9-day period) for *S. apache* (>228.5) in Christmas Tree Lake, 1978.

Gear	Captured	Recaptured	Exploitation rate
Trammel net	106	26	0.25
Hoop net	24	9	0.38
Angling	28	6	0.21
Totals	158	41	0.26

Population Estimates

Estimates of total number of *S. apache* in Christmas Tree Lake are with respect to lower size limits of fish. Mark and recapture experiments should utilize gear that is identical or near the same in efficiency for both phases (capture and recapture) of the experiment. The almost identical percentages of legal- and sub-legal-sized fish captured by angling and trammel netting (64 and 72%) suggested it was valid to use the total number (134) of fish captured by these two gear types and marked. Another factor which lends credence to combining fish captured by these two methods for population estimates is the equivalence of the exploitation rates of these two groups of fishes during the 9-day angling season (table 2).

Hoop nets, by contrast, captured a greater percentage (40 to 50%) of fish smaller than legal size. Also, exploitation rates were somewhat higher for this group of fish (table 2). As indicated above, trammel nets and angling never captured fish less than 228.5 mm in size whereas *ca.* 30% of the fish captured in hoop nets were less than this size. Accordingly, only those (24) fish which were greater than 228.5 mm in size (table 2) were utilized and combined with trammel net and angling data and population estimates were computed from these values. A population estimate of the legal-sized fish (>355.6 mm) also was made.

IPNV Analysis

No IPNV was detected in the 1978 samples of either brown or native trout from Christmas Tree Lake (table 3). A single native trout

Table 3.--Results of IPNV analyses for native and non-native salmonids in Christmas Tree Lake and streams on the Fort Apache Indian Reservation.

Date	Species	Specimens analyzed	Positive tests
	Christmas Tree Lake		
June 1975	S. apache	27	1
Oct. 1975	S. apache	48	0
	S. trutta	7	0
July 1978	S. apache	33	0
	S. trutta	30	0
	streams		
1977-78	S. trutta and S. gairdneri	99	4
	S. apache	83	0

tested positive for the virus in June 1975, however, almost 50 Arizona trout and 7 brown trout analyzed in October 1975 indicated the absence of IPNV.

Specimens of both non-native and native trout have been tested for IPNV on about a dozen streams throughout the Fort Apache Indian Reservation. No IPNV has been detected in natives, but a low collective occurrence (4.0%) of the disease has been demonstrated in brown and rainbow trout.

Taxonomic Analysis

Results of taxonomic analyses are in table 4. Eight fish examined from 1970 were rainbow in all morphometric measurements, but native in three meristics based on criteria used in Rinne (1978b). By comparison, all nine characters were native in seven specimens analyzed from 1971. Specimens from 1976 were native in anal fin base and the three meristics, yet rainbow in the remaining 5 morphometric proportions. The largest sample taken (1978) was again native in all three meristics, but was native only in dorsal fin depressed length and hybrid or rainbow in the remaining five characters.

DISCUSSION

The total number of S. apache in Christmas Tree Lake greater than 228.5 mm in size was 1,745 ± 362 (95% confidence limits) fish. By comparison, the population estimate of legal-sized S. apache was 746 ± 116 fish. Exploitation rates for legal-sized fish in 9 days (333/746) were quite high, approaching half of the estimated population.

Annual exploitation rates of lake populations of cutthroat trout (Salmo clarki Richardson) in the literature range from 0.06 to 0.10 (Bilton 1952, Bilton and Shepard 1955, Ball and Cope 1961). These values are 50 to 100% lower than the calculated rates for S. apache in Christmas Tree Lake but again are on an annual basis. Nevertheless, capture of a fourth of the larger fish (>228.5) and removal of almost half (45%) of the legal-sized fish from Christmas Tree Lake in about a third of a month indicates the ease with which this unfished lake population of wild trout could be overfished. This was substantiated in spring 1979 when only 3 of 26 fish (12%) fish captured by angling and 12 of 56 (21.8%) taken by trammel netting were greater than 355.6 mm. This is a dramatic reduction in the percentages (ca. 70%) of legal-sized fish taken by these same methods prior to the fishing season.

Table 4.--Results of taxonomic analyses of 9 characters for S. apache in Christmas Tree Lake, 1970-1978. Morphometric measurements are in thousands of standard length. Ranges for meristics are in ( ).

Year	n	SNL	DFB	DFDL	AFB	ANFDL	ADFDL	Scales above LL	Pyloric caecae	Vertebrae
1970	8	059R	153R	243R	117R	170R	097R	39.0N (35-42)	26.9N (22-33)	59.3N (58-61)
1971	7	088N	185N	314N	144N	209N	140N	37.2N (35-40)	22.8N (19-28)	59.1N (57-60)
1976	12	058R	157R	242R	125N	170R	092R	39.3N (38-40)	26.4N (21-31)	59.1N (58-60)
1978	41	058R	163H	263N	120H	172R	105H	34.7N (27-45)	29.9N (23-40)	59.2N (57-61)

SNL = snout length; DFB, dorsal fin base; DFDL, dorsal fin depressed length; AFB, anal fin base; ANFDL, anal fin depressed length; ADFDL, adipose fin depressed length; R = rainbow, N = native, and H = hybrid.

Schneider and Griffiths (1943) recorded a decrease in catch rate during a year of fishing for cutthroats in a small pond in Oregon. This occurred despite little change in population densities and indicates that negative conditioning may result in a reduced ease of capture by angling. This might be expected to occur in Christmas Tree Lake if long-term seasons were conducted and accordingly exploitation rates would decrease.

Catch rate in Christmas Tree Lake was low compared to those recorded in the literature for lake populations of the related cutthroat trout. A mean catch rate for cutthroats of one fish per man-hour (Bjornn 1961) to over 2.2 fish per hour has been recorded. In this study the lake was 50 times the size of Christmas Tree and the data were collected over a 168-day period. Moore et al. (1952) demonstrated that catch rates in Yellowstone Lake can vary widely (0.16 to 2.16 fish per hour). In this same study an average of only 11 tagged fish per 100 were captured by angling; half the same proportion (37 of 158) reported for Christmas Tree Lake. Higher catch rates on these larger lakes (relative to Christmas Tree) yet lower exploitation rates indicate the vulnerability to overfishing of this small, closed population of native Arizona trout.

Standing crop estimates for Christmas Tree Lake were made based on the total population (1,745) of fish over 228.5 mm. The average size of S. apache taken during the marking operation was 355 mm and 0.4536 kg. Using this average weight and densities of 103 fish per ha a standing crop of 46.7 kg/ha was computed. Harper (1978) reported mean standing crops of 130 kg/ha for S. apache in Big Bonito Creek. Similarly, Rinne (1978a) calculated a mean standing crop of 150 kg/ha for S. gilae in McKnight Creek, New Mexico. This is the first estimate of biomass of the Arizona trout in a lake environment and it is less than that recorded for stream populations and for cutthroats in ponds and rivers (51 kg/ha; Schneider and Griffiths 1943, Fleener 1952), and in lakes (99 kg/ha; Irving 1953).

The low standing crop of S. apache in Christmas Tree Lake compared to stream populations suggests food may be limiting in the lake. This statement held even if fish smaller than 228.5 mm (30% of the population based on hoop net catch) were considered. Stomachs of S. apache examined in summer 1978 contained only cladocerans. Mean condition factor ($KTL = W/TL^3$) for 99 fish in summer 1978 was 1.00. By comparison, mean condition for 30 S. apache in Ord Creek was 1.10 (Rinne et al. MS)[2]. Harper (1978) reported KTL for large (>240 mm) S. apache in Big Bonito Creek as 1.05 and at about 1.5 for fish from the East Fork of the White River. Mean values of condition listed for cutthroat trout in Schneider and Griffiths (1943) were 1.3 as based on standard length. If one converts the mean size of Christmas Tree Lake fish to standard length (divide by 1.18) and then calculates KSL, a mean value of 1.7 results, indicating a condition comparable to that of the related cutthroat.

Less than 1% of the 108 S. apache tested to date for IPNV in Christmas Tree Lake exhibited disease symptoms. By comparison almost 2.5% of all non-native specimens from streams on the Reservation tested positive. Once a population of fish becomes infected with IPNV little can be done to reverse the disease, and 90% or more mortality may result in fry and fingerlings (Amend 1976). Survivors are normally carriers. The presence of the disease in Christmas Tree Lake resulted from stocking hatchery fish. This conclusion is based on the greater incidence of the disease in the fish tested from streams throughout the Reservation and the fact that no IPNV was found in the three streams from which stock was derived for introduction in 1967. Laws and regulations exist that require a population to be certified specific-pathogen-free (SPF) for commerce or hatchery production (Herman 1970). This classification must be documented before a population can be designated as SPF. The last record of IPNV for Christmas Tree Lake was in 1975.

Samples taken since 1970 indicate the population of S. apache in Christmas Tree Lake is less than pure. This was evident in morphometric measurements--mostly fin/body size proportions and color patterns. The three meristic characters were consistently native over the 4 years suggesting that the lake environment modifies morphology so that fins become relatively smaller in a lentic environment. This rationale is, however, weakened by the completely native nature of all nine characters in seven fish collected in 1971 and that had inhabited the lake for 4 years. However, extreme variation in color observed in fish netted in summer 1978 indicated the presence of rainbow genes.

Disagreement between meristic and morphometric data for S. apache was also recorded in many streams sampled in the White Mountains (Rinne 1978b). In fact, 5 of 18 fish karyotyped from Deep Creek had types indicative of rainbow trout (i.e., 60 metacentric chromosomes). Similarly, one fish from Firebox Creek had a vertebral count of 62, also characteristic of rainbow. These data imply that some of the stock in 1967 was contaminated.

Phenotypic change through time in S. apache when in a lentic environment should be examined. Only two other mountain lakes in Arizona, Bear Canyon and Lee Valley, have been stocked with natives. The first population has been essentially destroyed by non-native salmonids that also inhabit this lake. The second has tributary streams into which fish from Soldier Creek (Rinne 1978a) were stocked as recently as autumn 1978. A fish barrier was constructed in 1979 to prevent upstream movement and interaction with brook trout, Salvelinus fontinalis (Mitchell). If some S. apache survive and grow in the lake then their phenotypic response (i.e., body color and fin growth) to lentic conditions should be examined.

We suggest S. apache in Christmas Tree Lake could have been contaminated by any of three means, acting alone or in combination. First, the purity of stocks from Deep and Firebox Creeks is suspect (Rinne 1978b). Second, the pure native stock from Ord Creek (Rinne et al., MS)[2] could have become contaminated while being reared in the hatchery with rainbow trout. Last, the presence of brown trout in Christmas Tree Lake implies the renovation of Sun and Moon creeks was incomplete, brown trout obviously survived and some hybrids between natives and rainbows that already inhabited the Diamond Creek system (Rinne 1978b) may also have done so.

MANAGEMENT IMPLICATIONS

Population estimates, rates of exploitation, angler success, and changes in population structure all suggest that S. apache in Christmas Tree Lake will not sustain heavy fishing pressure. A quality sport fishing can be maintained only under a proper balance of permits and number and lengths of seasons. If another season is conducted in 1979, either permits or season length should be reduced and the effect on the population should be determined again in spring-summer 1980.

This population of S. apache in Christmas Tree Lake could serve as brood stock to produce either eggs or offspring for introduction into local streams as recommended by the Arizona Trout Recovery Plan (USDI 1979) for this threatened species. The absence of IPNV again should be confirmed prior to adoption of such a program. The fish in the lake are large, eliminating the necessity of hatchery rearing to a larger size.

Using the population for brood stock is, however, precluded by the apparent impurity of it. This also needs resolution with regard to future sport fishing on this lake. Anglers are paying a fee to catch "golden" native trout. If, for example, two of a three-fish limit were more "blue-silver" in color anglers may become justifiably disturbed. Palatability differences between the two phenotypes undoubtedly is not detectable, but the relative cost to catch a "pure native" versus a rainbow trout is clearly evident. Also, anglers may wish to mount specimens. Both of these factors could have a negative effect on efforts to develop the native trout fishery.

Basically, the question is; "What happens to the population as anglers become more aware of the impure fish?" It is probable that apparent impure individuals, as they are caught, will be returned to the lake, even if legal-sized. This increases both time of angling and the chance of creeling three pure (based on color) native trout. The overall result for the lake is a conceivable shift from a partially impure population to one dominated by "rainbow-like" fish. Likelihood of a viable future native trout fishery on Christmas Tree Lake is therefore reduced.

Perhaps it is expedient to observe the phenotypic response of native trout reared in an experimental lake environment. However, if phenotypic changes would occur in a lake they also should be expected to develop under hatchery conditions. Based on color photographs and morphometric measurements (Rinne 1978b) of brood stock from Soldier Creek reared in the Sterling Springs Hatchery, alteration of characters will not occur. At this point we feel the suspect purity is a factor equally important to fishing pressure that must be resolved in order to successfully develop a sport fishery for this native trout in Christmas Tree Lake. Academically, data and observations to date may have already solved this problem. More practically, it is the angler who will decide the issue.

[2]Rinne, J. N., W. L. Minckley, and J. N. Hanson, MS. The chemical renovation of Ord Creek to restore the native Arizona trout, Salmo apache Miller.

LITERATURE CITED

Amend, D. F. 1976. Prevention and control of viral diseases of salmonids. J. Fish. Res. Board Can. 33(4):1059-1066.

Ball, O. P., and O. B. Cope. 1961. Mortality studies on cutthroat trout in Yellowstone Lake. U.S. Fish and Wildl. Serv. Res. Rep. 55, 62 p. Washington, D.C.

Bilton, T. H. 1952. The creel census of cutthroat trout of Lakelse Lake 1952, p. 18-20. In Fish. Res. Board Can., Prog. Rep. 92. Ottawa, Canada.

Bilton, T. H., and M. P. Shepard. 1955. The sports fishery for cutthroat trout at Lakelse Lake, British Columbia. p. 38-42. In Fish. Res. Board Can., Prog. Rep. 104. Ottawa, Canada.

Bjornn, T. C. 1961. Harvest, age structure, and growth of game fish populations from Priest and Upper Priest Lakes. Trans. Am. Fish. Soc. 90(1):27-31.

Fleener, G. G. 1952. Life history of the cutthroat trout, Salmo clarki Richardson in the Logan River, Utah. Trans. Am. Fish. Soc. 81:235-248.

Harper, K. 1978. Biology of a southwestern salmonid, Salmo apache, p. 99-111. In Proc. Wild Trout-Catchable Trout Symp. J. R. Moring (ed). [Eugene, Oreg. Feb 15-17, 1978] Ore. Dep. Fish and Wildl., Eugene, Oreg.

Herman, R. L. 1970. Prevention and control of fish diseases in hatcheries, p. 3-15. In A symp. on diseases of fishes and shellfishes. S. F. Snieszko (ed). Am. Fish. Soc. Spec. Publ. 5. Washington, D.C.

Irving, R. B. 1953. Ecology of the cutthroat trout, Salmo clarkii Richardson in Henrys Lake, Idaho. Unpubl. M.S. thesis, Utah State Ag. Coll. 101 p. Logan.

McDaniel, D. W. (ed.) 1975. Suggested procedures for the detection and identification of certain infectious diseases of fish. Fish Health Sec., Am. Fish. Soc.-Fish Wildl. Serv. Washington, D.C.

Moore, H. L., O. B. Cope, and R. E. Beckwith. 1952. Yellowstone Lake Trout creel censuses, 1950-51. U.S. Fish and Wildl. Serv., Spec. Sci. Rep.-Fish 81; 41 p. Washington, D.C.

Rinne, J. N. 1978a. Development and applicability of methods of population estimation and habitat evaluation for management of the Arizona and Gila trouts, p. 113-125. In Proc. Wild Trout-Catchable Trout Symp. J. R. Moring (ed). [Eugene, Oreg. Feb. 15-17, 1978] Ore. Dep. Fish and Wildl., Eugene, Oreg.

Rinne, J. N. 1978b. Distribution of pure populations of native Arizona trout Salmo apache Miller--A report to aid in the management and recovery of a threatened species of fish. Final rep. to office of endangered species, U.S. Fish and Wildl. Serv., Albuquerque, N. Mex. 60 p.

Schneider, P. W., and F. P. Griffiths. 1943. Production of trout in a small artificial pond in western Oregon. J. Wildl. Manage. 7(2):148-154.

Seber, G. A. F. 1973. The estimation of annual abundance. 506 p. Hafner Press, New York.

U.S. Department of Interior, Fish and Wildlife Service. 1979. Arizona trout recovery plan. Unnum. pgs. Albuquerque, N. Mex.

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